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ABSTRACT

This training unit on ventilation is part of a 17-unit course package written to aid instructors in the development, teaching, and evaluation of fire fighters in the Wisconsin Fire Service Certification Series. The purpose stated for the 8-hour unit is to familiarize the fire fighter with the needs for ventilation, the conditions that require it, and the skills and knowledge necessary to carry it out. An instructor's guide sheet provides this information: introduction to the topic, instructor preparation, length of unit, methods of instruction, testing, equipment and facilities required, recommended visual aids, and references. Following a list of unit objectives, a lesson plan outlines the main teaching points and states the preferred teaching method, cites the reference and page number(s) where the information is to be found, and indicates the necessary handouts. Other contents in the unit include a unit quiz, answer key to the quiz, and handouts (graphs, student worksheets, informational material, and forms). (YLB)

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FIRE SERVICE CERTIFICATION SERIES

UNIT FSCS-FF-13-81

VENTILATION

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VENTILATION

Prepared by:

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INTRODUCTION

This unit is designed to familiarize the candidate with the various needs for ventilation, the conditions that require it, and the skills and knowledge necessary to carry it out.

Upon completion of the unit, the candidate should be capable of making the basic decisions necessary and performing vertical, horizontal, forced and water fog ventilation.

Realistic ventilation situations will assist the candidate in understanding the need for, and value of ventilation.

INSTRUCTOR PREPARATION

Carefully study the objectives to determine the goals that have been set for the firefighters upon completion of this unit.

Review the lesson plans and if necessary, consult the references listed.

Develop suitable audio-visual aids, provide training area and necessary tools and equipment to effectively teach this unit.

LENGTH OF UNIT

Classroom Work	4 hours
Practical Skills	3 hours
Evaluation and Testing	1 hour

METHODS OF INSTRUCTION

Lecture or Illustration
and Demonstration

The discussion or conference method may be more useful when instructing the more experienced students.

Suggested methods and techniques are listed under Instructor's Notes on the lesson plans. For further information consult IFSTA Fire Service Instructor, 4th Edition pp. 57-77.

TESTING

At the end of this unit, a written quiz of five or more questions will be given.

EQUIPMENT AND FACILITIES REQUIRED

Classroom with necessary audio-visual equipment
Suitable ventilation simulations or mock-ups
Forcible entry tools as needed, axes, pike poles, saws, etc.
Ladders,hose, pumper, aerial ladder or platform if available and desired.

Suggested Visual Aids

Principles of ventilation in Fire Fighting Part I Ventilation Explained and Part II Ventilation performed also LAFD film "Ventilation" available from:
Film Communicators
N. Hollywood California 91607
or the film "Ventilation available from the National Fire Protection Association. Boston MA.

REFERENCES

1. Hudiburg, E. and McCoy, C., ed. Fire Ventilation Practices,#107, IFSTA, Stillwater 5th ed., 1970 pp. 1-7, 11-17, 21-41, 45-53

2. Hudiberg, E. and McCoy, C., ed., Fire Service Practices for Volunteer Fire Departments, #201, IFSTA, Stillwater, 5th ed., 1971, pp. 171-186

3. Peige, J., Ed., Essentials of Fire Fighting, # 200, IFSTA, Stillwater, 1st ed., 1977, pp. 2-11, 234-248.

4. Carlson, G., Ed., Fire Ventilation Practices, #107, IFSTA, Stillwater, 6th ed., 1980 pp. 1-115.

OBJECTIVES

All objectives in this unit are to be met according to the material contained in the International Fire Service Training Association Manuals #107 Fire Ventilation Practices 5th ed., or 6th ed., Fire Service Practices for Volunteer Fire Departments #201, and #200 Essentials of Fire Fighting.

To satisfactorily complete this unit, the fire fighter must attain a grade of 70 or higher on the written quiz and successfully complete the practical skills test.

NFPA STANDARD 1001

VENTILATION

Fire Fighter I

3-10 Ventilation

3-10.1 The fire fighter shall define the principles of ventilation, and identify the advantages and effects of ventilation.

3-10.2 The fire fighter shall identify the dangers present, and precautions to be taken in performing ventilation.

3-10.3 The fire fighter shall demonstrate opening various types of windows from inside, outside; with, and without the use of fire department tools.

3-10.4 The fire fighter shall demonstrate breaking window or door glass, and removing obstruction, without harm to self or others.

3-10.5 The fire fighter, given a fire axe, shall demonstrate the ventilation of a roof and a floor.

3-10.6 The fire fighter shall identify and explain the theory of a " back draft explosion."

Fire Fighter II

4-2 Ventilation

4-10.1 The fire fighter shall demonstrate the use of all different types of power saws and jack hammers used by the authority having jurisdiction.

4-10.2 The fire fighter shall identify the different types of roofs, demonstrate the methods used to ventilate each type, and identify the necessary precautions.

4-10.3 The fire fighter shall demonstrate how to determine the size of an opening for ventilation, how to locate these openings, and identify and explain the precautions to be taken during ventilation.

Fire Fighter II

4-2 Ventilation

4-10.4 The fire fighter shall demonstrate the removal of skylights, scuttle covers and other covers on roof tops.

4-10.5 The fire fighter shall demonstrate all different types of equipment for forced ventilation used by the authority having jurisdiction.

4-10.6 The fire fighter shall demonstrate ventilation using water fog.

COURSE: FIRE SERVICE CERTIFICATION SERIES

LESSON: VENTILATION

EQUIPMENT NEEDED: SLIDE, OVERHEAD OR MOVIE PROJECTOR, SCREEN

TRAINING AIDS: SLIDE, TRANSPARENCIES, FILMS, TEXTS

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices #107, IFSTA 6th Ed. pp. 1-118

Ref: Essential of Fire Fighting, #200 IFSTA, pp. 235-248

Ref. pp. 1-2 #107 6th ed.
Ref. pp. 235-236 # 200

Advantages of Ventilation

1. Aids lifesaving and rescue.
2. Speeds attack and extinguishment.
3. Reduces danger of back draft or smoke explosion
4. Reduces mushrooming.
5. Makes fire fighting easier.
6. Reduces damage from fire, smoke, water and heat.
7. Permits prompt salvage operations.
8. Helps to confine fire.

TEACHING POINTS

INTRODUCTION

Ventilation is the systematic removal of heated air, smoke and gases from a structure, followed by the replacement of these products of combustion with a supply of cooler air, which facilitates other fire fighting priorities.

The importance of ventilation becomes obvious:

. It increases visibility for quicker location of the seat of the fire.

. It decreases the danger to trapped occupants by channeling away hot, toxic gases.

. It reduces the chances of flashover or back draft.

Unfortunately, ventilation may be misunderstood by the public because it requires doing limited damage to a building; but is results in a much larger reduction in damage.

VENTILATION MUST BE PLANNED.

Proper ventilation cannot be accomplished haphazardly or independently of a well-planned fire attack.

Certain technical principles are involved.

A fire fighter cannot rely solely upon knowledge gained from practical experience, because no two fires are alike. Instead the fire fighter should begin with a basic study of ventilation theory and progress to the techniques of making the necessary openings in fire buildings for the removal of accumualted combustion products.

Remember: modern technology requires new emphasis on ventilation.

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices, #107, IFSTA 6th Ed. pp. 1-118

Ref: Essentials of Fire Fighting, #200, IFSTA pp. 235-248

Ref: pp. 1-2 #107 6th ed.
Ref: pp. 235-236 #200

TEACHING POINTS

INTRODUCTION

UNDERSTANDING OF VENTILATION NECESSARY

In order to function capably as a team member, a fire fighter needs to understand the characteristics and behavior of those elements and situations with which the fire fighter must contend.

It is not sufficient that ventilation be understood only by the senior officer in charge of a fire.

There are numerous instances during every involved fire for which each fire fighter must arrive at decisions and operate independently within the orders passed down from the senior officer.

It is a this point that the value of this training "pays off.

If the fire fighter has actively participated in a well-balanced, well-organized training program, which includes all aspects of the profession, the fire fighter will select the choice of alternatives that experience and training have taught is proper for the situation.

VENTILATION AIDS OTHER OBJECTIVES

Major objectives of a fire department are:

- To reach the scene of the fire as quickly as possible.
- To rescue trapped victims.
- To locate the fire.

and

- To apply suitable extinguishing agents with a minimum of fire, water smoke and heat damage.

Ventilation during fire fighting is definitely an aid to the fulfillment of these objectives.

To effectively and adequately achieve some of these objectives, it often becomes necessary to safely get inside a structure.

INSTRUCTORS NOTES	TEACHING POINTS
Ref: Fire Ventilation Practices, #107, IFSTA 6th ed. pp. 1-118	**INTRODUCTION**
	This problem emphasizes one reason why all fire companies should be equipped with adequate respiratory protection for each fire fighter.
Ref: Essentials of Fire Fighting, #200 IFSTA pp. 235-248	Although fire ventilation provides better breathing conditions within a structure, it does not remove all hazards and dangerous gases.
Ref: pp. 1-2 #107 Ref. pp. 235-236 #200	The application of water fog into a heavily charged, heated are may collect carbon particles from the smoke and disperse smoke and gases from the area, BUT IT DOES NOT ELIMINATE THE NEED FOR RESPIRATORY PROTECTION.
	Fire ventilation is conceded to be vitally essential in fire control, yet there are factors and conditions that also influence the success or failure of an operation.
	Failure to provide for all conditions as they arize may jeopardize and entire operation.
	However, when proper ventilation is accomplished to aid fire control there are certain advantages that may be obtained from its application.
3-10 Ventilation	**PHASES OF FIRE**
3-10.1	Fires may start at any time of the day or night if the hazard exists.
Ref: pp. 5-6 #107 Ref: pp. 235-36 #200	If the fire happens when the are is occupied, the chances are that it will be discovered and controlled in the beginning phase.
	But if it occurs when the building is closed and deserted, the fire may go undetected until it has gained major proportions. The condition of a fire in a closed building is one of chief importance for ventilation.
	When fire is confined to a building or room, a situation develops that requires carefully calculated and executed ventilation procedures if further damage is to be prevented and danger reduced. This type of fire can be best understood by an investigation of its three progressive stages.
	A fire fighter may be confronted by one or all of the following phases of fire at any time; therefore, a working knowledge of these phases is important for the understanding of ventilation procedures.

INSTRUCTORS NOTES	TEACHING POINTS
Ref: Fire Ventilation Practices, #107, IFSTA 6th Ed. pp. 1-118	**PHASES OF FIRE** Incipent or Beginning Phase
Ref: Essentials of Fire Fighting, #200 IFSTA pp. 235-248	In the first phase, the oxygen content in the air has not been significantly reduced and the fire is producing:
3-10 Ventilation	water vapor (H_2O)
3-10.1	carbon dioxide (CO_2)
	perhaps a small quantity of sulfur dioxide (SO_2)
	carbon monoxide (CO)
Ref: p. 5 #107 6th ed. Ref. pp. 25-29 #105 5th ed.	and other gases.
	. Slightly over 100 degrees F. (27 degrees C) in the room
Refer to Handout #1	. Rising hot gases
	. Room air approximately 20% oxygen.
	Some heat is being generated, and the amount will increase with the progress of the fire.
	While the fire may be producing a flame temperature well above 1,000 degrees F. (537 degrees C), the temperature in the room at this stage is relatively low as shown.
	Free-Burning Phase
	The second phase of burning encompasses all the free burning activities of the fire:
	During this phase, oxygen-rich air is drawn into the flame as convection (the ries of heated gases) carries the heat to the uppermost regions of the confined area:
	The heated gases spread out laterally from the top downward, forcing the cooler air to seek lower levels, and eventually igniting all the combustible material in the upper levels of the room.
	Fire fighters must wear respiratory equipment and keep low in this atmosphere. One breath of this superheated air can sear the lungs.

INSTRUCTORS NOTES	TEACHING POINTS
Refer to Handout #2 Ref: Fire Ventilation Practices, #107, IFSTA, 6th ed., pp. 1-118	Free Burning Phase
	Temperature in upper regions approximately 1,300 degrees F. (700degrees C),
Ref: Essentials of Fire Fighting, #200, IFSTA pp. 235-248	In latter stages fire consumes free oxygen until reaching a point where ther is insufficient oxygen to react with the fuel.
3-10 Ventilation 3-10.1	Fire is then reduced to the smouldering phase and needs only a supply of oxygen to burn rapidly or explode.
Ref: p.p. 6-7 #107 6th ed. Ref: pp. 25-29 #107 5th ed.	Smouldering Phase
Refer to Handout #3	In the third phase, flame may cease to exist if the area of confinement is sufficiently airtight.
	Burning is reduced to glowing embers.
FREE BURNING PHASE Approximately 1300 degrees F. (537 degrees C)	Room becomes completely filled with dense smoke and gases to the extent that it is forced from all cracks under pressure.
Heat accumualtes at upper areas	Fire will continue to smoulder, completely filling the room with dense smoke and gases of combustion at a temperature of well over 1000 degrees F. (537 degrees C.).
Reduced oxygen supply. SMOULDERING PHASE	The intense heat will have vaporized the lighter fule fracti such as hydrogen and methane from the combustible material in the room.
Oxygen below 15% Temperature throughout is high.	These gases will be added to those produced by the fire and will further increase the hazard to the firefighter and create the possibility of a backdraft.
High CO and carbon concentration	PRODUCTS OF COMBUSTION
	When a material (fuel) burns, it undergoes a chemical change
	None of the elements making up the material are destroyed in the process, but all of the matter is transformed into another form or state.
	The products of combustion equal in weight and volume the weight and volume (although dispersed) of the fuel before it was burned.
	When a fuel burns there are four products of combustion: . fire gases , heat . flame . smoke

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices, #107, IFSTA, 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting, #200, IFSTA, pp. 235-248

3-10 Ventilation

3-10.1

Ref; pp. 6-7 #107 6th ed.
Ref: pp. 25-29 #107 5th ed.

TEACHING POINTS

PRODUCTS OF COMBUSTION cont.

HEAT is a form of energy measured in degrees of temperature to signify its intensity.

Heat is the product of combustion that is responsible for the spread of fire.

It is the direct cause of burns and other forms of personal injury.

Injuries caused by heat include:

. dehydration

. heat exhaustion

. injuries to the respiratory tract

. burns

FLAME is the visible, luminous body of a burning gas.

When a burning gas is mixed with the proper amounts of oxygen, the flame becomes hotter and less luminous.

This loss of luminosity is beacuse of a more complete combustion of the carbon.

For these reasons, flame is considered to be a product of combustion.

. Heat

. Smoke

and

. Gas however, can develop in certain types of smouldering fires without evidence of flam.

The smoke encountered at most fires consists of a mixture of:

. oxygen - nitrogen - carbon dioxide - carbon monoxide -

finely divided particles of soot and carbon,

and

a miscellaneous assortment of products that have been released from the material involved.

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices, #107, IFSTA, 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting, #200, IFSTA pp. 235-248

3-10 Ventilation

3-10.1

Ref: pp. 7-8 #107 6th Ed.
pp. 25-29 #107 5th e

TEACHING POINTS

SMOKE AND GASES

The term FIRE GASES refers to the vaporized products of combustion.

The more common combustible materials contain carbon, which when burned forms:

. carbon dioxide (CO_2)

and

. carbon monoxide (CO)

The principal factors that determine the fire gases that are formed by burning are:

. Chemical composition of the fuel

. Amount of oxygen present for combustion

and

. the temperature of the fire.

Most fire gases are toxic and will cause death or serious injury if inhaled in sufficient doses.

The mechanism by which the toxic fire gases inflict their harmful effects varies somewhat between the various fire gases.

In general, fire gases like:

. carbon dioxide

. carbon monoxide

and

. hydogen cyanide

will cause asphyxiation by disrupting the body's natural respiratory processes.

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices, #107, IFSTA, 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting, #200, IFSTA pp. 235-248

3-10 Ventilation

3-10.1

Ref: pp. 8-12 #107 6th ed
pp. 24-29 #107 5th e

TEACHING POINTS

SMOKE AND GASES cont.

Other fire gases such as :

. hydrogen chloride (HCl)

. hydrogen sulfide (H_2S)

. sulfur dioxide (SO_2)

. ammonia (NH_2)

and

. oxides of nitrogen

cause excessive irritation in the respiratory tract, resulting in pulmonary edema.

These irritations, some of which may appear minor, may in a few days develop into exceedigly disastrous complications and/or death.

FIRE GAS CHARACTERISTICS AND EFFECTS

The following expresses the harmful effects of failing to wear proper protective equipment including breathing apparatus while performing rescue, fire fighting or salvage and overhaul operations.

THESE GASES ARE PRODUCED IN MOST FIRES WELL IN EXCESS OF THE AMOUNT NECESSARY TO BE CONSIDERED DEADLY.

Many gases found in fire buildings have a specific gravity greater than 1.0, meaning they are heavier than air at normal temperatures and would normally be found near the floor.

However, because gases expand and become lighter as they are heated, the gases tend to rise.

Most of the gases encountered in a fire building are hot since they are products of combustion; thus the greatest concentration of these gases are likely to located in the upper portions of a fire room.

NOTE: If the fire is extinguished without complete ventilatio the heavy, heated gases will cool and return to lowere levels DURING OVERHAUL This phenomenon proves the NECESSITY FOR CONTINUED USE OF PROTECTIVE BREATHING APPARATUS.

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices, #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

3-10 Ventilation

3-10.1

Ref: pp. 8-12 #107 6th ed.
pp. 24-29 #p07 5th ed.

TEACHING POINTS

FIRE GAS CHARACTERISTICS AND EFFECTS

Ammonia

A colorless gas with a sharp characteristic odor.

Strong irritant of the:

eyes
nose
throat
lungs

Symtoms and signs from exposure include:

- swelling of eyelids
- irritation of the nose and throat
- coughing
- vomiting
- difficulty breathing
- irritation to moist skin

Carbon Dioxide

Oderless and colorless gas.

Inhalation of the gas diminished the ability the body blodds ability to remove the CO2 produced at the cells of body tissue.

It also stimulates the breathing rate of an individual, which in turn van increase the inhalation of other toxic fire gases.

Moreover, this reduces the amount of oxygen reaching the body tissue through the bloodstream.

At slightly higher-than-normal levels of carbon dioxide in the bloodstream, the individual will experience:

- headaches
- mental excitement
- dizziness
- sweating

in addition to

- increased lung ventilation.

Ref: Fire Ventilation Practices, #107, IFSTA, 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

3-10 Ventilation

3-10.1

Ref: pp. 8-12 #107 6th ed.
pp. 24-29 #107 6th ed.

FIRE GAS CHARATERISTICS AND EFFECTS

Still higher concentrations of carbon dioxide in the bloodstream can paralyze the respiratory center of the brain (caused by insufficient oxygen supply) and lead to death by asphyxiation.

Carbon Monoxide

A colorless , oderless gas that acts as a chemical asphyxiant.

Combines with the hemoglobin in the blood 210 times faster than oxygen, thereby reducing the blood's ability to carry sufficient oxygen for supporting life functions of the body tissue.

Also hinders the removal of carbon dioxide from the bloddstream by the lungs.

As the concentration increases in the bloodstream, the individual will experience:

. shortness of breath

. dizziness

. mental confusion

. impairment of vision and hearing

and

. eventual collapse.

THESE SYMTOMS ARE NOT READILY PERCEIVED BY THE AFFLICTED PERSON.

Hydrogen Chloride

A colorless gas.

When inhaled, it reacts with the moisture of the body tissue in the respiratory tract to form HYDROCHLORIC ACID, which causes a strong irritation.

The primary effect of an irritant gas such as hydrogen chloride is to cause edema at some level in the respiratory tract resulting in a blockage by fluids.

Additionally, irritated tissue on the walls may swell up sufficiently to block the passage of air.

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Fire Ventilation Practices, #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting, #200, IFSTA pp. 235-248

3-10 Ventilation

3-10.2

Ref: pp. 8-12 #107 6th ed.
pp. 24-29 #107 5th ed.

FIRE GAS CHARACTERISTICS AND EFFECTS

Hydrogen Chloride cont.

Either of these conditions can lead to suffocation.

Will also react with water vapor in the atmosphere to form HYDROCHLORIC ACID which has a detctable pungent odor.

The hydrochloric acid will condense in the atmosphere and form a white mist that will be visible.

However, this white mist may be easily covered up or hidden by other products of combustion during a fire.

Symptoms and signs include:

- coughing
- irritating apin in the respiratory tract
- breath holding

Hydrogen Cyanide

Colorless gas with the faint odor of bitter almonds.

Becomes chemically attached to blood preventing transfer of oxygen from the blood to cells of the body tissue.

It causes death by asphyxiation

It is classified as a CHEMICAL ASPHYXIANT

Signs and symptoms of exposure are:

- headaches
- dizziness
- unsteadyness of gait
- feeling of suffocation or nausea

Hydrogen Sulfide

Colorless gas with a strong "rotten egg" odor.

Irritating effect on the upper respiratory tract leading to pulmonary edema.

Pulmonary edema blocks the body's natural respiration process and leads to death by suffocation.

INSTRUCTORS NOTES	TEACHING POINTS

Ref: Fire Ventilation Practices, #107, IFSTA, 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting, #200, IFSTA pp. 235-248

3-10 Ventilation

3-10.2

FIRE GAS CHARACTERISTICS AND EFFECTS

Oxygen Deficiency is a condition of the fire atmosphere caused by the consumption of oxygen because of the combustion. The following table and Handout #4 explain the sysmptom for concentration of oxygen lower than the normal percentage in the atmosphere (21%).

Ref: #107 6th ed. pp. 8-12
pp. 24-29 #107, 5th ed.

Refer to Handout #3

OXYGEN DEFICIENCY

Percentage of Oxygen in the Atmosphere	Symptoms
17	Reduced muscular coordination increased respiratory rate
15	Free burning ceases
12	Dizziness, headache, quick fatigue
9	Unconsciousness
6	Death within a few minutes from respiratory and concurrent heart failure

Nitrous Fumes, prodiced by the burning of cellulose nitrates are EXTREMELY DANGEROUS.

The term NITROUS FUMES covers a wide range of oxides of nitrogen.

The oxides of nitrogen produce what may appear to be minor irritations, which may develop in a few days into exceedingly disastrous complications, even death.

There are two oxides of nitrogen that are dangerous:

- nitrogen dioxide
- nitric oxide

NITROGEN OXIDE is the most significant oxide of nitrogen, since nitric oxide would readily convert to nitrogen dioxide in the presence of oxygen and moisture.

Nitrogen Dioxide is a pulmonary irritant that has a reddish brown color.

If inhaled is sufficient concentration, will cause pulmonary edema.

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices, #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting, #200, IFSTA pp. 235-248

3-10 Ventilation

3-10.2

Ref: pp. 8-12 #107 6th ed.
pp. 24-29, #107 5th ed.

TEACHING POINTS

FIRE GAS CHARACTERISTICS AND EFFECTS

Nitrogen Dioxide is an insidious gas IN THAT ITS IRRITATING EFFECTS IN THE NOSE AND THROAT MAY BE TOLERATED EVEN THOUGH A LETHAL DOSE IS BEING INHALED.

Therefore, its hazardous effects from either its pulmonary irritation or chemical reaction may not become apparent for several hours after initial exposure.

All oxides of nitrogen are somewhat soluble in water and react in the presence of oxygen to form NITRIC AND NITROUS ACIDS.

These acids are neutralized by the alkalis present in the body tissues and form nitrites and nitrates.

These substances chemically attach to the blood and can induce:

- nausea
- vomiting
- abdominal pains
- cyanosis (skin discoloration from oxygen deficiency in the blood)

which can lead to collapse and coma.

Also, nitrites and nitrates can cause:

- arterial dilation
- variation in blood pressure
- headaches
- dizziness

The effects of nitrites and nitrates are secondary to the irritant effects od nitrogen dioxide but can become important under certain circumstances, causing delayed physiological reactions from exposure to the oxides of nitrogen.

Sulfur Dioxide

a colorless gas that has a highly irritating property that makes it detectable below its lethal dosage.

Sulfur dioxide is produced when materials containing sulfur are burned.

This gas is SUFFOCATING but nonflammable.

IT IS HIGHLY TOXIC IN CONCENTRATIONS OF 400 PARTS PER MILLION.

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices, #107, IFSTA 6th ed., pp. 1-118

Ref: Essentials of Fire Fighting, #200, IFSTA pp. 235-248

3-10 Ventilation

3-10.2

Ref: pp. 8-12 #107 6th ed.
pp. 24-29 #107 5th ed.

TEACHING POINTS

FIRE GAS CHARACTERISTICS AND EFFECTS

Other Irritants

- acetic acid
- acetic anhydride
- formaldehyde
- furfural
- acetaldehyde
- acrolein
- formic acid

These organic compounds are strong irritants with acid odors. Like most irritants, they are generally tolerable at levels below their toxic levels.

Carbon Monoxide has certain flammability characteristics that should be understood.

The flammable range of carbon monoxide is between

12.5 and 74 percent

The ignition temperature is approximately

1200 degrees F. or 650 degrees C.

This means that a mixture of 12.5 percent carbon monoxide with 87.5 percent air will flame when heated to its ignition temperature.

In this situation carbon monoxide is considered to be at its

LOWER EXPLOSIVE LIMIT

A mixture of 74 percent carbon monoxide and 26 percent air will explode when heated to its ignition temperature

This condition is said to be at the

UPPER EXPLOSIVE LIMIT

SINCE IT IS EXTREMELY DIFFICULT TO ASCERTAIN WHAT GAS PRESENT, PROTECTIVE BREATHING APPARATUS SHOULD ALWAYS BE WORN in contaminated atmospheres.

Some materials give off more smoke than others.

Liquid fuel - dense black smoke

INSTRUCTORS NOTES	TEACHING POINTS
Ref: Fire Ventilation Practices, #107, IFSTA 6th ed. pp. 1-118	Oils Tar Paint Varnish Molasses Sugar Rubber Sulfur
Ref: essentials of Fire Fighting, #200, IFSTA pp. 235-248	and many plastics also generally give off a dense smoke in large quantities.
3-10 Ventilation	The openings in a building may contribute to the accumulation of smoke in the areas not otherwise affected by the fire.
3-10.2 Ref: pp. 12-15 #107 6th ed. pp. 29-32 #107, 5th ed.	If the fire occurs in one end of a room and if a vertical opening is in the opposite end, the smoke and gas often must travel the length of the room to make its escape.
	Thus, the entire room may be filled before the smoke shows on upper floors, especially if the fire occurs in the basement,
	If the wind is from the side where the fire starts, it may provide enough pressure inward to spread the smoke and gases throughout the building.
	Connections with adjoining buildings may afford the possibility of smoke appearing in those buildings rather than the one in which the fire exists.
3-10 Ventilation	Backdraft
3-10.6	Firefighters responding to a confined fire that is late in the free-burning phase or in the smouldering phase risk causing a backdraft or smoke explosion if the building is not properly ventilated.
Refer to Handout #4	In the smouldering phase of the fire, burning is incomplete because not enough oxygen is available to sustain the fire.
	However, the heat from the free-burning phase remains, and the unburned carbon particles and other flammable products of combustion are just waiting to burst into rapid almost instantaneous combustion when more oxygen is supplied.
	Proper ventilation releases smoke and the hot unburned gases from the upper areas of the room or structure.
	Improper ventilation at this time supplies the dangerous missing link - OXYGEN.
	As soon as the needed range of oxygen is admitted the resulting combustion is devastating in its speed, and truly qualifies as an explosion.

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices, #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting, #200, IFSTA pp.235-248

3-10 Ventilation

3-10.6

Ref: pp. 12-15 #107 6th ed
pp. 29-32 #107 5th ed

TEACHING POINTS

Backdraft

Combustion is related to oxidation and oxidation is a chemical reaction in which oxygen combines with other elements.

Carbon is a naturally abundant element present in wood, among other things.

When wood burns carbon combines with oxygen to form Carbon Dioxide (CO_2) or Carbon Monoxide (CO) depending on the availability of oxygen.

When oxygen is no longer available, free carbon is released in the smoke.

A warning sign of possible backdraft is dense black (carbon filled) smoke.

When oxygen is reintroduced into the area, it combines with the carbon, and the smoke becomes less black, turning instead to yellow or grayish yellow.

"BACKDRAFT" !!!!!!

This could have been prevented by removing the unburned carbon particles and the heat.

By doing this, the addition of oxygen would not complete the fire tetrahedron in a dangerous way. Instead the cooling air would make subsequent fire fighting easier.

The following characteristics may indicate a backdraft or smoke explosion condition:

- Smoke under pressure
- Black smoke becoming dense gray yellow
- Confinement and excessive heat
- Little or no visible flame
- Smoke leaves the building in puffs or at intervals
- Smoke stained windows
- Muffled sounds
- Sudden rapid movement of air inward when opening is made.

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices #107, IFSTA, 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting, #200, IFSTA pp. 235-248

3-10 Ventilation

3-10.1
3-10.2
3-10.6

Ref: pp. 15-17, #107 6th ed.
PP. 29-32 #107, 5th ed.

TEACHING POINTS

BACKDRAFT

This type of condition can be made less dangerous by proper ventilation.

The building should be opened at the highest point involved, the heated gases and smoke will be expelled, reducing the possibility of an explosion.

TRANSMISSION OF HEAT

Heat can travel throughout a burning building by one or more of four methods.

- Conduction
- Radiation
- Convection
- Flame Contact

Since the existence of heat within a substance is caused by molecular action, the greater the molecular activity, the more intense the heat.

A number of natural laws of pHysics are involved in the transmission of heat.

One of these is the LAW OF HEAT FLOW; it specifies that heat tends to flow from a hot substance to a cold substance.

The colder of the two bodies in contact will absorb heat until both objects are the same temperature.

Conduction

The process of conduction is generally associated with heat transfer, rather than flame.

Heat may be conducted from one body to another by direct contact of the two bodies or by an intervening heat conducting medium.

The rate of heat transfer and travel will depend on the conductivity of the material through which the heat is passing.

Not all materials have the same heat conductivity.

Aluminum, copper and iron are good conductors, while fibrous materials such as felt, cloth and paper are poor conductors.

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices, #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting, #200, IFSTA pp. 235-248

3-10 Ventilation

3-10.1
3-10.2
3-10.6

Ref: pp. 15-17 #107 6th ed
pp. 29-32 #107 5th ed.

Refer to Handout #6

Refer to Handout #7

Convection
Direct Flame Contact

TEACHING POINTS

TRANSMISSION OF HEAT

Conduction

Liquids and gases are poor conductors of heat because of the movement of their molecules.

Air is a relatively poor conductor of heat.

Radiation

Radiated heat will travel through space until it reaches an opaque object.

As the object is exposed to heat radiation, it will in turn radiate heat from its surface.

Radiated heat is one of the major sources of fire spread.

It is important that immediate precautions be taken at any point where radiation exposure is severe.

Convection

Convection is the transfer of heat by the movement of air or liquid.

Heated air in a building will expand and rise.

For this reason fire spread by convection is mostly in an upward direction, although air currents can carry heat in any direction.

Convected currents are generally the cause of heat mpvement from floor to floor, from room to room, and from area to area.

The spread of fire through corridors, up stairwells and elevator shafts, between walls, and through attics is mostly caused by convection of heat currents.

It has more influence on the positions for fire attack and ventilation than either radiation or conduction.

Direct Flame Contact

Fire also spreads along and through a material taht will burn by direct flame contact.

When a substance is heated to the point where flammable vapors are given off, these vapors may be ignited. any other flammable material in contact with the burning vapors or flame may be heated to a temperature where it too, will ignite and burn.

INSTRUCTORS NOTES

Ref: Fire Ventilation
Practices #107, IFSTA
6th ed. pp. 1-118

Ref: Essentials of Fire
Fighting #200, IFSTA
pp. 235-248

4-10 Ventilation

4-10.2

Ref: pp. 21-26 #107 6th ed.
Ref: pp. 43-60 #107 5th ed.

Refer to Handout #2 Unit 12
Forcible Entry

Refer to Handout #1 Unit 12
Forcible Entry

TEACHING POINTS

GENERAL BUILDING CONSTRUCTION FEATURES

Most modern buildings have continous masonry foundations of:

. concrete

. brick

or

. stone

upon which the building rests.

The foundation walls that support frame construction may extend well above the ground.

Exterior walls may be constructed of:

masonry

masonry veneer

metal

or wood frame

Masonry walls most desirable:

Fire resistant and usually 8 to 12 inches thick depending upon the particular material used.

Masonry venner walls are essentially frame walls in which the supporting members are wood or metal with a veneer of one layer of brick or stone on the exterior to give the appearance of a solid brick or stone wall.

The upright wooden or metal supporting members in wood frame or masonry veneered waslls are called studs.

These are usually 2 x 4 inch size spaced at 16, 18, or 24-inch intervals. The presence of these studs creates hollow spaces in the walls through which fire can spread. Fire stops should be provided in these hollow spaces.

Frame Walls are constructed of:

wood or wallboard sheathing fastened to studs.

With exterior siding, asbestos shingles, stucco or other types of exterior finish applied over the sheathing.

Frame walls also have hollow spaces in them that are create
by the studs and should be fire-stopped.

Ref: Fire Ventilation Practices, #107, IFSTA 6th ed., pp.1-118

Ref: EEssentials of Fire Fighting, #200, IFSTA pp. 235-248

4-10 Ventilation

4-10.2

Ref: pp. 21-26, #107 6th ed.
pp. 43-60 #107 5th ed

FIRE STOPS

Refer to Handout #1 Unit 12 Forcible Entry

Refer to Handout #8

Fire Stops

Are construction members that are placed in walls, partitions and ceilings, between the studs at each floor level, and at the upper end of the stud channels in the attic.

These fire stops cut off draft within the walls and help cpntrol the spread of fire and smoke.

Fire Walls

are self-supporting walls designed to maintain structural integrity even in case of a major collapse of the structure.

Fire walls should extend through and above combustible roofs to prevent the spread of fire in attics or on roofs.

If fire walls are constructed properly, it should not be necessary to perform ventilation on the opposite side of the wall.

However, if fire walls have unprotected openings, holes or poke-throughs, ventilation will have to be performed on the other side of the wall.

Fire walls should be checked during routine fire department company building surveys and inspections in order to determine if the walls are constructed and maintained properly.

Prefabricated Steel Buildings

Are constructed with a steel I-beam frame with thin sheets of steel or aluminum placed over the frame.

Some of the older buildings have poles or columns in place of I-beams as a form of support.

Insulation is placed inside the steel siding and dry wall is then placed over the insulation.

It is IMPORTANT for the firefighter to remember THAT THE ROOF IS MAD IN THE SAME MANNER AS THE WALLS.

Many times plastic skylights are placed on the roof.

They have been known to melt out before the arrival of the fire department and thus aid the firefighter in ventilation.

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices, #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

4-10 Ventilation

4-10.2

Ref: pp. 21-21 #107 6th ed.
pp. 43-60 5th ed.

TEACHING POINTS

Prefabricated Steel Buildings

CAUTION

These buildings have been known to collapse when the internal temperature is 1,000 degrees F. (538 degrees C.) or more.

When firefighters must be sent to the roof to ventilate, the use of aerial ladders or elevated platforms is recommended.

Firefighters sent to the roof should look for:

signs of discoloration or sagging and if an aerial or platform is not available use a roof ladder to distribute their weight over a larger area.

The fire offcier MUST make a proper size up of the fire situation BEFORE sending firefighters to the roof for ventilation and inside for initial attack, in order to prevent injury to the firefighter.

High-Rise Buildings

A major consideration in high-rise buildings is the danger to occupants from heat and smoke.

Occupants of the building must be made aware of the reasons for, and the necessity of:

- proper fire prevention procedures

and

- what actions they should take in the event of fire.

They should be taught:

- The value of closed doors in preventing the spread of fire, smoke heat and gases.
- How to transmit a fire alarm.
- How to alert other occupants.
- The operation of fire extinguishers and standpipe equipment.
- How to prevent smoke from entering their rooms, by sealing cracks and closing vents.
- How to obtain fresh air if trapped in a room.

INSTRUCTORS NOTES	TEACHING POINTS
Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118 Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248 4-10 Ventilation 4-10.2 Ref: pp. 21-26 #107 6th ed pp. 43-60 #107 5th ed.	High Rise Buildings Architects have attempted to solve high-rise problems by: . fire-resistive construction . vertical enclosures and . compartmentation but they are defeated by flammable decorative materials and furnishings. High-rise buildings are normally occupied by hospitals, apartments or business offices. In any case a great number of people may be exposed to danger if proper engineering, education and enforcement is not provided. Doors to stairway enclosure are frequently left, or propped open, allowing smoke and heat to be drawn into hallways and rooms. STAIRWAY ENCLOSURE DOORS MUST BE AUTOMATIC CLOSING AND MUST BE KEPT CLOSED. In high-rise facilities, fire and smoke may spread rapidly through: . pipe shafts . stairways . elevator shafts . air handling systems and other vertical openings.
Refer to Handout #9	These shafts contribute to a "stack effect" creating an upward draft and interfering with evacuation and ventilation.

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

4-10 Ventilation

4-10.2

Ref: pp. 21-26 #107 6th e
pp. 43-60 #107 5th ed.

TEACHING POINTS

High-Rise Buildings

Elevators frequently become an undesirable means of transportation during fire fighting operations because of:

- electrical failure
- doors being held open on the fire floor because of activation of the electric eye mechanism by smoke

or

- the car being automatically recalled to the fire floor.

As a result, elevators MUST be equipped with manual override system to provide safe operation by fire department personnel.

Ventilation in high-rise buildings to be successful must be based on specific plans for effective use of:

- personnel
- equipment

and

- extinguishing agents.

You must remember that the personnel required for this type of building is approximately four to six times as great as required for a normal residence fire.

In most instances, ventilation must be accomplished horizontally;

- on the level involved by fire

and

- immediately above the fire where smoke and heat have spread.

Protective breathing apparatus will be needed in a larger than normal supply, since every firefighter will have to be completely equipped for every eventuality.

The problems of communication and coordination between the various attack and ventilating teams become more involved as the number of participants increases.

INSTRUCTORS NOTES	TEACHING POINTS
Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118	**High-Rise Buildings** Sufficient personnel must be available to provide frequent relief for both ventilating and fire attack crews.
Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248	**Stratification of Smoke and Fire Gases**
4-10 Ventilation	The creation of layers of smoke and fire gases on floors below the top floor of a sealed multistory building is a relatively new phenomenon.
4-10.2	
Ref: pp. 21-26 #107 6th ed.	Smoke and fire gases produced will accumulate at various levels until the building is ventilated.
pp. 43-60 #107 5th ed.	Pre-fire planning should include tactics and strategy that can cope with the ventilation and life hazard problems inherent in stratified smoke.
Ref: pp. 27-28 #107 6th ed.	Heat escapes to the environment as smoke and fire gases travel through a building.
pp. 43-63 #107 5th ed.	The products of combustion rise through any vertical opening until their temperature is reduced to the temperature of the surrounding air.
Refer to Handout #10	when this stabilization of temperature occurs, the smoke and fire gases form layers or clouds within the building.
	Experience has shown that these dense smoke clouds form at a level below the top floor.
	Example: A fire occurred in the basement of a 17-story sealed building.
	Dense smoke clouds formed on the 10th, 11th and 12th floors.
	The fire was extinguished before sufficient heat built up to move the stratified smoke to the top floor.
	Ventilating this cooled smoke out of the top of the building was accomplished by creating controlled currents of air up the stairshafts and across the smoke filled floors.
	Mushrooming
	This effect, which is usually expected on top floors, does not occur in tall buildings until sufficient heat is built up to move the stratified smoke and fire gas clouds that have gathered on lower floors in an upward direction.

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices #107 IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

4-10 Ventilation

4-10.2

Ref: pp. 28-29 #107 6th ed.
pp. 43-63 #107 IFSTA 5th ed.

NOTE: During ventilation occupants and firefighters must not enter this shaft, because of the deadly chimney effect above the fire floor.

TEACHING POINTS

High-Rise Buildings

Top ventilation of serious fires in modern tall buildings must be considered during pre-fire planning.

In many buildings only one stairshaft pierces the roof.

This vertical "chimney" must be used to ventilate smoke, heat and fire gases from various floors.

Before the doorways on the fire floors are opened and the stairshaft is ventilated, the uppermost door to this stairshaft must be blocked open in a very secure manner or removed from its hinges.

REMOVAL IS RECOMMENDED AS IT IS IMPERATIVE THAT THE DOOR CANNOT BE CLOSED WHICH WOULD ALLOW THE SHAFT TO BECOME FILLED WITH SUPERHEATED GASES AFTER VENTILATION IS BEGUN.

If this is not done properly, firefighters would not have any other way of re-opening the door other than from the roof side.

TIMING AND COORDINATION OF TACTICS ARE EXTREMELY IMPORTANT.

DO NOT use this method of ventilation until all occupants above the fire floor are either evacuated or warned to stay out of the stairwell "chimney" and firefighters are known to be IN A SAFE POSITION.

Once the decision is made to ventilate this way, the stairway is useless for rescue operations, access and escape.

Prior knowledge of stairway layout is imperative.

Imprper ventilation through a dead-end stairshaft can only seriously delay;

. the extinguishment of fire

and

. increase fire damage.

Because the windows cannot be opened, common horizontal ventilation procedures may be impractical in newer buildings.

Mechanical ventilation up a stairshaft, across a smoke filled floor, and out through the roof by way of another stairshaft is the usual ventilation tactic in sealed buildings.

INSTRUCTORS NOTES | TEACHING POINTS

REF: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

4-10 Ventilation

4-10.2

Ref: pp. 28-30 #107 6th ed. .
pp. 43-63 #107 5th ed

Underground Structures and Windowless Buildings

Except in private dwellings, basements are required to have;

- outside stairways
- windows

or

- hoistways

to provide firefighters access.

These are not normally required when the basement is sprinklered.

Most basements and subbasements have outside entrances such as;

- stairways
- elevators
- chutes

or

- windows

However, at the ground level they may be blocked or secured with;

- iron gratings
- steel shutters
- wooden doors

or a combination of these.

Vault-type doors may be found on;

- fallout shelters
- fur and bank vaults

If an outside entrance is provided, it is frequently sealed weathertight and locked for protection aginst burglars.

INSTRUCTORS NOTES

Ref: fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

4-10 Ventilation

4-10.2

Ref: pp.28-30 #107 6th ed
pp. 43-63 #107 5th ed.

TEACHING POINTS

Underground Structures and Windowless Buildings

All of these features serve to impede attempts at natural ventilation.

An important factor that should be considered when a basement is involved in fire is its relationship to the main structure.

Building features such as

. stairways	. elevator shafts
. pipe chases/shafts	. laundry chutes
. air handling systems	. other vertical openings

contribute to the spread of fire and smoke to upper floors.

Ventilation below street level is difficult in that it presents problems that are not encountered in ventilating above street level.

Underground structures rarely provide an opportunity for normal ventilation.

BASEMENTS USUALLY REQUIRE MECHANICAL VENTILATION.

Many buildings, especially in the business area, have windowless wall areas.

Although windows are not usually a desirable escape route from buildings that are burning, they are

. most important during ventilation and rescue.

Normal evacuation routes may frequently be blocked or made impassable during fires, and windowless buildings present a serious problem for trapped occupants.

Windowless building designs also create an adverse effect on fire fighting and ventilation operations.

The hazards is windowless buildings are increased due to the fact that ventilation may be delayed for considerable time, allowing the fire to gain headway or creating backdraft conditions.

Windowless buildings usually require the use of MECHNICAL VENTILATION for the removal of smoke.

[illegible]

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

4-10 Ventilation

4-10.2

Ref: pp.28-30 #107 6th ed. pp. 43-63 #107 5th ed.

Underground Structures and Windowless Buildings

It is IMPERATIVE that firefighters become THOROUGHLY FAMILIAR with the

- design
- systems
- contents
- access routes

in windowless buildings in their area.

Management and occupants should be made aware of such items as will enhance the safety of occupants and assist in fire prevention and fire fighting efforts.

Roof Construction

Many designs and shapes of roof styles are used and their names vary in each locality.

Refer to Handout #21 Unit 12 Forcible Entry

Some of the more common styles are:

- flat
- gambrel
- hip
- dome
- butterfly
- gable
- shed
- mansard
- lantern
- arched

Dwelling roofs are usually built of wooden supporting members called rafters to which roof sheathing is fastened.

To the roof sheathing is fastened or applied the roof covering material.

Refer to Handouts # 22-23 Unit 12 Forcible Entry

Roof coverings may be:

- wooden shingles
- composition roofing paper
- slate
- composition shingles
- tile
- built up tar and gravel surface.

The roof covering in the exposed part of the roof, and its primary purpose is to afford protection against the weather.

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

4-10 Ventilation

4-10.2

Ref: pp.30-36 #107 6th ed.
pp. 43-63 #107 5th ed.

TEACHING POINTS

Roof Construction

The selection of a proper roof covering is important from a fire protection standpoint because it may be subjected to sparks and blazing brands if a nearby building should burn.

Foamed-in-place roofs using synthetic foaming materials such as urethanes and isocynates are becoming more common.

These roofs are being used for two reasons:

- low maintenance cost
- high insulation qualities

Caution should be exercised when such roofs are encountered, because the flammability characteristics of some types are unknown.

Also the insulating qualities of the material could trap heat, leading to weakening or failure of the roof.

When opening such roofs, a charged line should ALWAYS be advanced to the roof in the event that the foam materials ignite and burn.

Protective breathing equipment should ALWAYS be worn for protection against toxic fumes released from burning foams.

Vertical (top) ventilation is directly related to roof construction and to vertical openings.

A study of the more common types of roofs and the manner in which their construction affects ventilation practices is necessary to develop effective vertical ventilation procedures.

The Flat Roof

Flat roofs are more common to:

- mercantile buildings
- multiple dwellings
- industrial buildings
- apartment complexes

than to single-family dwellings.

This type of roof orinarily has a slight slope to the rear of the building and is frequently pierced by:

- chimneys
- scuttles
- vent pipes
- skylights
- shafts

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, Ifsta pp. 235-248

4-10 Ventilation

4-10.2

Ref: pp.30-36 #107 6th ed
pp. 43-63 #107 5th ed.

Refer to Handouts #22-23 Unit 12 Forcible Entry for examples of flat roof construction.

Note: The same type of truss is being used to support floors.

TEACHING POINTS

The Flat Roof

The roof may be surrounded and divided by parapets, and it may be expected to support:

- water tanks
- airconditioning equipment
- antennas
- or other obstructions

that may interfere with ventilation operations.

The structural part of a flat roof is generally similar to the construction of a floor

- wooden concrete or metal rafters covered with a sheathing.
- sheathing is covered with a waterproof layer and an insulating material.

Underneath the flat roof there is generally a concealed possibly unvented, space that is formed when the ceiling is installed.

These concealed spaces or voids, complicate ventilation procedures and fire fighting to a great extent.

Ventilators or pipe shafts may terminate in this space, and they can only be detected by complete inspections.

CAUTION

Some flat roos are being constructed with chords of wood in the trusses. These roofs can be dangerous because the wooden chords of the trusses that support it burn through rapidly.

Firefighters working on flat roof should look for signs of:

- heat or
- sagging of the roof

Serious consideration should be given to the use of roof ladders to distribute the firefighters weight over a larger area to help prevent falling through a weakened roof.

Overhangs are often added to flat-roofed buildings to give the appearance of a mansard roof. These overhangs form concealed spaces through which fire and smoke can spread quickly and unseen. Although they are not an integral part of the building, they might have to be opened. Overhanging cornices might present the same problem.

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

4-10 Ventilation

4-10.2

Ref: pp. 30-36 #107 6th ed
pp. 43-63 #107 5th ed.

Refer to Handout #25 Unit 12 Forcible Entry for examples of pitched roof construction.

TEACHING POINTS

The Pitched Roof

A pitched roof is any roof that is elevated in the center, thus forming a pitch to the edges.

Pitched roof construction usually involves timber rafters or wooden or steel trusses that run from the ridge to a wall plate on top of the outer wall at eaves level.

These rafters carry the sloping roof, which can be constructe of various materials.

Ceiling joists are fastened to the wall plate and rafters so the assembly forms a series of triangles.

In the average home, the space between the roof members and the ceiling forms an attic space.

These attic spaces are normally vented by louvers in each gable end, and netrance can be made to the attic by a small opening in the ceiling, usually in a hallway or closet.

There may also be a stairway leading to the attic.

Insulation material that may or may not be combustible may be found between the framing under the roof or on top of the ceiling.

The Arched Roof

Arched roofs have demonstrated many desirable qualities for certain types of buildings.

The lower chord of the truss may be covered with a ceiling t form an enclosed cockloft or roof space.

Such concealed, unvented spaces are definitely a hindrance to ventilation practices and contribute to the spread of the fire.

A trussless arched roof has been developed that is made up o relatively short timbers of uniform length.

Trussless arch construction enables all parts of the roof to be visible to firefighters.

A hole of considerable size may be cut or burned through the network sheathing and roofing at any place without causing collapse of the roof structure, since the loads are distributed to less damaged timbers ariund the opening.

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

4-10 Ventilation

4-10.2

Ref: pp.30-36 #107 6th ed
pp. 43-63 #107 5th ed.

Refer to Handout #11

The Bowstring Truss Roof

In a bowstring truss roof, the arched member is dependent on all of the members holding it together.

If one member fails, it is likely that the entire unit will fail.

Many times truss units are attached to other truss units.

When one unit collapses it pulls down the roof and the other truss units, causing the front and rear walls to be pushed out.

When the tension on a bowstring roof is released by the bottom chord burning through, pressure is applied to the outside walls and can cause the collapse of the side walls as well as the roof.

Bowstring truss roofs are commonly found in such occupancies as bowling alleys and supermarkets.

Roof Openings

Firefighters should take advantage of natural roof openings whenever possible in accomplishing ventilation.

In many instances, roof stairway doors, hatches, skylights, ventilator openings and elevator shafts can be used in vertical ventilation, thus eliminating the need to cut through roofs.

Venting Devices

Vents are not intended to be a substitution for fire-detecting or extinguishing systems, but they have proven effective in releasing the heated gases, reducing smoke damage and retarding the spread of fire.

Curtain Boards

Are used to trap and retard the spread of smoke and heat.

In addition to performing these two functions, curtain boards used in conjunction with a vent, serve to increase the height of the stack.

In the theory of draft, the effectiveness of the vent will be increased proportionately to the difference between the temperature of the air in the stack and the outside air.

The higher stack created by the curtain board confines the heated air, keeping it from spreading out, thus increasing the temperature in the stack,

INSTRUCTORS NOTES	TEACHING POINTS
Ref: Fire Ventilation Practices #107 IFSTA 6th ed. pp. 1-118 Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248 4-10 Ventilation 4-10.2 Ref: pp. 36-39 #107 6th ed pp. 43-63 #107 5th ed.	

Curtain Boards

should be constructed of noncombustible material and should extend from the roof or ceiling to a height above the floor necessary to restrict the spread of heat and smoke horizontally through the open areas of the building.

The areas covered or protected will generally be governed by local codes.

Monitors

Monitor vents are usually rectangular projections through the roof of single story buildings.

The monitor may have metal, glass, wire glass or louvered sides.

The type with glass sides depends upon the glass breaking to provide venting in case of fire.

The type with solid walls should have at least two opposite sides hinged at the bottom and held closed at the top with afusible link arrangement to facilitate their opening in case of fire.

Continous Gravity Vents

Continous gravity vents are the unbroken narrow slot openings similar to those frequently found along the gables of pitched roofs.

They are usually covered with weather hoods.

If they are equipped with temperature control shutters, they should be of the type that automatically opens in case of fire.

Unit TType Vents

Unit type vents are normally constructed of metal frames and walls and operate by a hinged damper controlled either manually or automatically.

They may be found in various sizes from 4 by 4 feet to 10 by 10 feet, distributed throughout the roof.

Their location and number are determined by the requirements of the occupancy.

INSTRUCTORS NOTES	TEACHING POINTS
Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118	Automatic Heat and Smoke Vents Firefighters should become acquainted with methods of operation and the manual release mechanisms of automatic heat and smoke devices.
Ref: Essentials of Fire Fighting #200, IFSTA pp. @35-248	When pre-planning structures note:
4-10 Ventilation	. the location of vents
4-10.2	. methods of manual release
Ref: pp. 36-39 #107 6th e pp. 43-63 #107 5th ed.	. donot use forcible entry practices on these devices as this can be dangerous due to the spring loading and other devices on this equipment.
	. forcible entry at these devices will cause extensive damage and create danger for the firefighters.
	. DO use mechanical ventilation at these vents when they are operating to assist in the removal of smoke and gases.
	Skylights
Refer to Handout #25 Unit 12 Forcible Entry.	. are effective if they contain ordinary glass that will break and fall out as the temperature of the fire increases and aid in venting the structure.
	. Those containing wired glass have little or no value unless the fram is counterweighted and secured with a fusible link arrangement that will open them in the event of fire.
	. they also may be removed by firefighters although this effort is time consuming and should be avoided if other effective means of ventilation are available.
	Air Conditioning Systems
See NFPA Standard No.90-A Air Conditioning and Ventilating Systems.	Can be adopted for limited use in control of smoke.
	These systems are not made to handle high-temperature smoke and fire gases, but they can prove to be an auxiliary method in smoke control.
	If the air conditioning system is able to create a greater pressure in the areas UNINVOLVED IN FIRE, this pressure will be exerted toward the fire areas, reducing smoke migration into the uninvolved areas.

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

4-10 Ventilation

4-10.2

Ref: pp. 36-39 #107 6th ed.
pp. 43-63 #107 5th ed.

TEACHING POINTS

Automatic sprinkler heads

Discharging water after a fire has been controlled tends to retard the ventilation of smoke.

HOWEVER, AUTOMATIC SPRINKLERS MUST BE LEFT ON UNTIL COMPLETE EXTINGUISHMENT IS CERTAIN, BECAUSE UNDER SMOKY CONDITIONS HIDDEN FIRES COULD STILL BE PRESENT.

Automatic smoke and heat vents may not automatically operate when activated sprinkler heads are discharging close to them.

The sprinklers may control the fire and heat development to a level that would not activate the automatic smoke and heat vents by melting the fusible-link.

Exterior Wall Windows

That reach near the ceiling may be of great value as vents.

Windows that are lower are not as effective, since the hottest air will flow to the ceiling.

The top windows on the leeward side of the building should be opened first, if conditions will permit horizontal ventilation from the point of their location.

Occupancy and Contents

The type of occupancy of a building determines the degree and nature of the hazard, along with the fire potential that may exist.

Occupancy hazards are equally as important as construction features in relation to the study of ventilation.

Special factors that will have a direct bearing on the ventilation procedure include:

- Number and location of personnel who can be expected to occupy the building.
- The extent to which escape routes may be blocked or rendered inaccessible by the fire or smoke, and alternative routes available.
- The quantity and type of combustibles that make up the contents.
- The location of these combustibles.
- The toxicity and explosion hazards of the contents.

INSTRUCTORS NOTES	TEACHING POINTS
Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118	Occupancy and Contents . Fire-detecting and extinguishing systems available.
Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248 4-10 Ventilation 4-10.2	Requirements for Ventilation Before a fire officer directs or orders a ventilation operation, , a series of decisions must be made that will, by the nature of the fire situations, fall into the following order:
Ref: pp. 36-39 #107 6th ed. pp. 43-63 #107 5th ed.	First Decision Is there need for ventilation at this time ? The answer to this question must be based on: . the life hazard . the extent of the fire . heat, smoke and gas conditions within the structure.
	Second Decision Where is ventilation needed ? The answer to this question involves: . exposures . extent of fire . location of fire . wind direction . construction features of building . vertical openings . horizontal openings

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

3-10 Ventilation

3-10.1

Ref: pp. 43-47 #107 6th ed
pp. 65-80 #107 5th ed.

TEACHING POINTS

Requirements for Ventilation

Third Decision

What type of ventilation should be used ?

The answer to this question may be derived from a fire occicer's knowledge of the following three methods of ventilation:

- providing an opening fro the passage of air between interior and exterior atmospheres
- using the application of water fog and the expansion of water into steam to displace contaminated atmospheres
- using mechanical (forced) ventilation

Modern energy conservation policies may create ventilation problems since insulation blown into buildings may cause flashover to occur much faster.

This is because the insulation will retain heat much better and will thus raise the temperature of combustibles in the fire area to ignition temperature much more quickly than is normally anticipated.

Therefore, the need for ventilation is increased and must be accomplished much sooner than has been practiced in the past.

Insulation installed over roof coverings of fire-rated roof construction will effectively retain heat and may reduce the fire rating dratically, causing premature roof fsilure.

When a fire officer determines the need for ventilation, the precautions that may be necessary for the control of the fire and the safety of the firefighters must also be considered:

- full protective clothing
- protective breathing apparatus
- charged hoselines

should be provided during ventilation.

The possibility of fire spreading throughout a building and the danger of exposure fires ARE ALWAYS PRESENT.

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200 IFSTA pp. 235-248

3-10 Ventilation

3-10.1

Ref: pp. 43-47 #107 6th ed
pp. 65-80 #107 5th ed.

TEACHING POINTS

Requirements for Ventilation

Visible Smoke Conditions

Smoke conditions will vary according to how the burning has progressed.

A free-burning fire must be treated differently from one in the smouldering stage.

Smoke accompanies most ordinary forms of combustion, and it differs greatly with the nature of the substances being burned and the amount of available oxygen.

In addition to the gaseous products of combustion, other constituents such as

. tar . unburned carbon

and ash are drawn upward by the draft created by the heat of the fire.

A fire that is just starting and consuming wood, cloth or other ordinary furnishings will ordinarily give off

gray white or blue white

smoke of no great density.

As the burning continues

. the density may increase

. the smoke may be come darker due to the presence of large quantities of carbon particles.

Black smoke is usually the result of burning hyrocarbon such as:

rubber-tar roofing-oil-plastics

It has been said that brown smoke might indicate

nitrous fumes

and

gray yellow smoke is a danger signal of an approaching

backdraft

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

3-10 Ventilation

3-10.1

Ref: pp. 43-37 #107 6th ed
pp. 65-80 #107 5th ed.

Refer to Handout #12

TEACHING POINTS

Visible Smoke Conditions

ALTHOUGH THE COLOR OF SMOKE MAY BE OF SOME VALUE IN DETERMINING WHAT IS BURNING, SMOKE COLOR IS NOT ALWAYS A RELIABLE INDICATOR.

Several possibilities must be considered when determining where to ventilate:

. smoke coming out of a lower story, may indicate that openings are blocked above the point where smoke appears

. smoke coming through only one end of a building, may indicate the location of the fire or it may be the result of wind direction

. smoke coming out around the roof, through openings, around skylights, pent houses, scuttle holes and through small openings in the wall usually indicates a confined fire that has gained much headway.

It may be lazily drifting out into the atmosphere or it may be coming out with a great deal of force.

Smoke Odors

It is sometimes quite easy for firefighters to clssify what is burning by distinctive ordors, especially during the early stages of fire:

Smoke from:

. burning rubber
. electrical insulation
. pine wood
. food
. rags
. feathers

or grass all have a characteristic odor and will permit a firefighter to determine what kind of material is burning.

Providing Fire Control

BEFORE VENTILATING A BUILDING. A FIRE OFFICER MUST PROVIDE SUFFICIENT PERSONNEL AND ADEQUATE EQUIPMENT FOR FIRE CONTROL

THE FIRE MAY IMMEDIATELY INCREASE IN INTESITY WHEN THE BUILDING IS OPENED.

These resources should be provided for both the building involved and other exposed buildings.

INSTRUCTORS NOTES

Ref: Fire Ventilation
Practices #107, IFSTA
6th ed. pp. 1-118

Ref: Essentials of Fire
Fighting #200, IFSTA
pp. 235-248

3-10 Ventilation

3-10.1

Ref: pp. 43-47 #107 6th ed
pp. 65-80 #107 5th ed.

TEACHING POINTS

Providing Fire Control

As soon as the building has been opened to permit hot gases and smoke to escape, the next requirement is to reach the seat of the fire for extinguishment.

Entrance should be made into the building through a door, window, or some such opening as near the fire as possible if wind direction will permit.

It is at this opening that charged lines should be in readiness in case of violent burning or explosion.

Charged hoselines should also be made available at other points where openings are made to protect buildings that are likely to be endangered because of their exposure to the one involved.

HOSE STREAMS SHOULD NOT BE DIRECTED INTO VENTILATION OPENINGS CREATED BY THE FIRE OR FIREFIGHTERS BECAUSE THIS WILL DEFEAT THE VENTILATION PROCESS AND MAY ENDANGER PERSONS INSIDE THE BUILDING.

IN ADDITION, THIS ACTION MAY FORCE FIREFIGHTERS IN THE BUILDING TO ABANDON THEIR ATTACK POSITIONS AND ALLOW FIRE TO EXTEND INTO UNINVOLVED PORTIONS OF THE BUILDING.

Heat Conditions and Fire Severity

Firefighters may obtain an indication of the intensity of the heat by feelings walls, doors or windows.

Hot spots will indicate the probable travel of the heat or location of the fire.

A lower level fire may sometimes be located by a hot spot on the floor above it.

A LITTLE TIME FOR CONSIDERATION IS WORTHWHILE WHEN DETERMINING PROPER VENTILATION PROCEDURES. THE POINT AND METHOD OF ATTACK SHOULD BE WELL ESTABLISHED.

Life Hazards to Occupants

In some fires; conditions may suggest:

. that ventilation come first to draw away heat and smoke

or

. thatthe spreading flames be attacked immediately

sometimes both must be done simultaneously.

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

3-10 Ventilation

3-10.1

Ref: pp. 47-53 #107 6th ed
pp. 65-80 #107 5th ed.

TEACHING POINTS

Life Hazards to Occupants

All variables cannot be discussed here, but the point is that the first consideration is the safety of occupants.

Potential Hazards to Fire Service Personnel

In addition to the hazards that endanger occupants, their are potential hazards to firefighters and rescue workers.

. the type of structure involved

. whether natural openings are adequate

. the need to cut through roofs, walls or floors

add more problems to the decision process.

The hazards to be expected in a closed building that contains a smouldering fire are:

. life hazards

. fire hazards

and

. backdraft hazards

A review of the nature of smoke and gases during a fire reveals the following potential hazards:

. the obscurity caused by dense smoke

. the presence of poisonous gases

. the lack of oxygen for breathing

. the presence of flammable gases

. serious damage to the structure

Since a fire may raise the temperature in a room to well over 1,000 degrees F. (538 degrees C.). a firefighter who has a basic knowledge of the ignition temperature of various materials may estimate the temperature in a room by the degree of involvement of the materials affected.

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

3-10 Ventilation

3-10.1

Ref: pp. 47-53 #107 6th ed
pp. 65-80 #107 5th ed.

The ignition temperatures of some materials commonly found in buildings are given below:

IGNITION TEMPERATURE OF COMMON COMBUSTIBLES

Dry wood (approximately)	500 degrees F.	(260 degrees C.)
Paper (newsprint)	451 degrees F.	(232 degrees C,)
Cotton cloth	439 degrees F.	(226 degrees C.)
Pyroxylin plastice	275 degrees F.	(135 degrees C.)

Performing Rescue Work

WHEN IT BECOMES NECESSARY TO RESCUE OCCUPANTS FROM IMMINENT DANGER IN A BURNING BUILDING, OBVIOUSLY THIS TASK SHOULD BE GIVEN PRIORITY OVER ALL OTHER ACTIVITIES.

Rescue procedures would necessarily be different during each phase of fire.

During the first phase, rescue might not be required at all.

During the second phase, rescue and ventilation might be performed simultaneously.

During the third phase, before the building is throughly ventilated, rescue procedures may become externely difficult.

This difficulty may be because of the

. lack of oxygen

. obscured vision

. the presence of toxic and noxious gases

. high temperatures

and

. backdraft hazards.

Rescue procedures include:

. entering the building

. locating the victims

. releasing and removing the victims

and self-protection.

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

3-10 Ventilation

3-10.1

Ref: pp. 47-53 #107 6th e
pp. 65-80 #107 5th ed.

TEACHING POINTS

Performing Rescue Work

Entering a building may be necessary by forcible entry,

and, unless the fire has reached the third phase,

entry may be made where desired.

If the third phase has been reached, the point of entrance should be made ONLY AFTER VENTILATION HAS BEEN ACCOMPLISHED.

Anticipating the Situation

Anticipation is a process of visualizing something that is not, at the moment, present before the eyes.

Anticipation must be based upon facts and existing condition because a future course of action depends upon these two factors.

The following sequence of anticipating is suggested. which is the first stage of size up:

. time of day

. occupancy

. probable location of the fire

. contents (probable fuel involved

. composition of fire gases

. type of building

. anticipated action of fires burning freely

. anticipated action of smouldering fires

Gathering the Facts

Facts concerning the situation are gathered after arrival at the fire.

Facts upon which ventilation procedures may be based include:

. rescue
. type of construction
. indications of flame, smoke, smoke odor and heat

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

3-10 Ventilation

3-10.1

Ref: pp. 47-53 #107 6th ed
pp. 65-80 #107 5th ed.

TEACHING POINTS

Evaluating the Facts

The act of evaluating the facts is purely a mental procedure.

The following list of conditions and requirements are not intended to be in order of their importance, but the facts concerning them should be considered before any procedure or course of action is established.

Personal Protection
Personnel & Equipment
Rescue requirements
Occupancy
Location of fire
Extent of fire
Exposures

Extinguishment method
Building construction
Weather conditions
Material burning
Smoke and gas travel
Fire travel

Determining the Procedures

With the

. situation anticipated

. facts gathered

. facts considered

a fire officer can determine the procedures by which ventilation is to carried out.

The following sequence of procedures is recommended:

Ways to Ventilate

. Top/vertical; for example opening roofs and skylights
. Cross/horizontal: for example, opening windows and doors
. Mechanical/forced; for example, smoke ejector and water fog

Rescue Procedure

. Establish need
. Use most desirable method

Fire Protection Requirements

. Exposures protected
. Charged lines in place
. Communications established

INSTRUCTORS NOTES	TEACHING POINTS
Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118	Determining the procedures
Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248	Ventilation Procedure • Place(s) to ventilate • Time to ventilate • Methods of ventilation
3-10 Ventilation 3-10.1	Extinguishment Procedures • Place(s) to enter • Methods of extinguishing
Ref: pp. 47-53 #107 6th ed. pp. 65-80 #107 5th ed.	

VENTILATION PROCEDURES

HAZARDS INVOLVED IN VENTILATION	POSSIBLE CONSEQUENCES	APPROVED PRACTICE
Life hazards to firefighters	Roof collapse Explosions below Bad smoke and gas conditions Escape difficult in emergency Injury from other's use of tools	Paint top 18 inches of ladders (reflective white) Know building construction in advance If doubtful, lay ladder flat on roof Delay lower openings for ventilation above Know contents of building Cut from winward side of opening Place escape rope Two persons cutting work from diagonally opposite corners of cut Have charged line at opening
Ventilation delayed	Backdrafts Roof unsafe Entire building involved Excessive losses increased life hazard	Prompt decisions Prompt action
Public criticism	Hurts reputation of department Lowers morale of department Lessens public support Promotes political interference Lowers department efficiency	Know buildings in advance Know principles of ventilation Know proper methods of ventilation Use judgement Do a workmanlike job Explain department practices to public Explain reasons for ventilation Admit your mistakes Have department trained and disciplined Have knowledge of smoke and gases

VENTILATION PROCEDURES

HAZARDS INVOLVED IN VENTILATION	POSSIBLE CONSEQUENCES	APPROVED PRACTICE
Opening below fire	Backdraft No ventilation No value	Open above fire
Opening too soon	Lines not laid Fire gets away Increased loss Additional work time Additional life hazard	Lay and charge lines simultaneously Be prepared to fight the fire
Opening wrong place	No ventilation Backdraft Spread fire to area not involved Increased loss Additional work time Additional life hazard Adverse criticism	Have previous knowledge of building Open over vertical shafts Know contents Know hallways and partitions
Opening into blind attic	No ventilation Backdraft Loss of time additional loss Additional hazard	Have previous knowledge of building Use pike pole to open ceiling below
Insufficient opening	Ineffective ventilation Backdraft Loss of time Additional loss Additional hazard	Open large enough hole in first place Know size and location of areas below
Involement of exposures	Spread of fire Increased loss Additional work time Additional life hazard	Know surrounding buildings in advance Know horizontal openings Know roof structures Watch wind direction and velocity Have lines covering exposures Know heat and gases

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

3-10 Ventilation

3-10.2

Ref: pp. 57-60 #107 6th ed
pp. 80-96 #107 5th ed.

TEACHING POINTS

One common method by which smoke and heat may be removed from a burning building is by opening the structure at a strategic place to permit smoke and heat to escape.

This method may be applied to top or vertical ventilation as well as to cross or horizontal ventilation.

The Building Involved

It has already been pointed out that knowledge of the building involved is a great asset when making decisions concerning ventilation, particularly when top or vertical ventilation is to be applied.

Special construction features such as

. staircases
. shafts
. dumbwaiters
. ducts

and roof openings are determining factors.

Checking building permits will often reveal information concerning

. heating, ventilating and air conditioning systems

. type of roof construction

. roof openings

and

. avenues of escape for smoke, heat and gases.

Inspection and pre-planning of all buildings with emphasis on construction, is necessary for the application of proper ventilating procedures.

Locating the Fire'

In most instances ventilation should not be carried out until the location of the fire is established.

Smoke that is coming out of the top floor does not always indicate a fire on the top floor.

The fire may be on a lower floor or even in the basement.

INSTRUCTORS NOTES

Ref: Fire Ventilation
Practices #107, IFSTA
6th ed. pp. 1-118

Ref: Essentials of Fire
Fighting #200, IFSTA
pp. 235-248

3-10 Ventilation

3-10.2

Ref: pp. 57-60 #107 6th ed
pp. 80-96 # 107 5th ed.

TEACHING POINTS

Locating the Fire

Opening for ventilation purposes before the fire is located may spread the fire throughout areas of the building that would not otherwise have been affected.

The fire may be located by feeling

. walls

. windows

or

. roof

to determine heat conditions.

Smoke that is gently flowing from an opening is not necessarily close to the seat of the fire. Obviously extensive roof ventilation may be impractical or externely dangerous if the location of the fire is such that vertical ventilation will draw the fire into parts of the building that are not involved.

The location of the fire may be accurately determined by a proper system of size up.

The fire may have traveled some distance throughout a structure by the time fire fighting forces arrive, and consideration must be given to the extent of the fire as well as its location.

The severity and extent of the fire usually depends upon

. kind of fuel

. time it has been burning

. installed fire protection devices

. degree of confinement of the fire

The phase to which the fire has progressed is a primary consideration in determining ventilation procedures.

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

3-10 Ventilation

3-10.2

Ref: pp. 57-60 #107 6th ed
pp. 80-96 #107 5th ed.

Refer to Handouts #14-15

TEACHING POINTS

Some of the ways by which vertical extension occurs are as follow:

- Through stairwells, elevators and shafts by direct flame or by convected air currents
- Through partitions and walls and upward between the walls by flame contact and convected air currents
- Through windows or other outside openings where flame extends to other exterior openings and enters upper floors
- Through ceilings, walls and floors by conduction of heat through beams, pipes or other objects that extend from floor to floor or room to room
- Through ceilings and floors by direct flame contact
- Through floor and ceiling openings where sparks and burning material fall through to lower floors
- By collapse of floors and roofs

Personnel and Equipment for Ventilation

In pre-fire planning, drills and in actual fire fighting designated firefighters should automatically determine access to the roof.

They may gain access by the use of

- extension ladders
- aerial ladders

or

- elevating platforms not needed for rescue activities.

They may use fire escapes or stairways within the building or in adjoining buildings if this can be done safely.

Standard operating procedures can be adopted that will insure the "spotting" of the areial ladders or platforms at every fire and drill.

This practice will save considerable time in ventilation and attack procedures.

INSTRUCTORS NOTES	TEACHING POINTS
Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118	Personnel and Equipment for Ventilation Practically every forcible entry tool can be applied to ventilation.
Ref: essentials of Fire Fighting #200, IFSTA pp. 235-248	. axe and pry bars to open hatches and roof access doors
3-10 Ventilation	. wire and bolt cutters for removing locks and guy wires
3-10.2	. pike poles for pushing away ceilings after initial roof entry has been made
Ref: pp.	. axes, disc or chain saws or oxyacetelene torch for cutting openings
	The experienced firefighter will attempt to carry most of the tools through necessary to the roof.
	If additional equipment is needed either
	. return to the ground for it
	. hoist it up by rope
	or
	. have another member of the fire fighting unit deliver it.
4-10 Ventilation	Using Natural Roof Openings
4-10.4	Once firefighters have reached the roof, observed the condition of the fire (smoke), and the determination is amde to open the roof, they should first look to natural openings for providing necessary ventilation if other conditions favor such opening.
	Natural openings may exist in many forms:
	. scuttle hatches . skylights . monitors . ventilation shafts . stairway doors
	are some of the more common openings provided that lend themselves to vertical ventilation.
	All of these may expected to be locked or secured in some manner against entry.

INSTRUCTORS NOTES	TEACHING POINTS
Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118	Using Natural Roof Openings Scuttle hatches are normally small square metal-covered hatches that provide entrance into attic or cocklofts.
Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248	If the scuttle hatch is to be used, the ceiling directly below the hatch may require removal.
4-10 Ventilation	Skylights should be removed, in preference to breaking the glass, if possible.
4-10.4	Pry flashings loose on all sides and lift the skylight off completely.
Ref:60-65 #107 6th ed. Ref: pp.80-96 #107 5th ed.	An alternative way would be to pry loose three sides and use the fourth side as a hinge.
	The sides of a monitor may contain glass (which is easily removed) and louvers of wood or metal.
	The sides that are hinged are easily forced at the top.
	If the top of the monitor is not removable, at least two sides should be opened to create the required draft.
	Stairway doors may be forced open in the same manner as other doors of like type.
	Roof obstructions can either help or hinder during ventilation operations.
	These obstructions may be air conditioning equipment, processing vents, machinery vents, dust collection units and a variety of other items
4-10 Ventilation	Selecting the Place to Ventilate
4-10.3	OPEN OVER THE FIRE
	There is no rule of thumb for selecting the exact point to open a roof except "AS DIRECTLY OVER THE FIRE AS POSSIBL
	Many factors will have a bearing om where to ventilate.
	Some of them are: . the availability of natural openings (skylights, ventilator shafts, monitors, hatches, etc.) . location of the fire and the direction in which the chief officer wishes it to be drawn

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

4-10.3 Ventilation

4-10.3

Ref: pp. 60-65 #107 6th ed
pp. 80-96 #107 5th ed.

TEACHING POINTS

Selecting the Place to Ventilate

- type of construction
- wind direction
- the extent the fire has progressed
- the condition of the building and its contents

The person accomplishing ventilation should also be constanly aware of the effect that ventilation will have on the fire and the consequence it will have on exposures.

Prior to opening the building, consideration should be giver to the department's state of readiness and ability to protect exposures.

Top-Level Ventilation Procedure

Prior to and during the actual opening of the roof, the officer in charge should give consideration to the following items:

- coordinate with ground and attack companies
- observe the wind direction with relation to exposure
- note existence of obstructions or weight on the roof
- secure a lifeline to the roof or provide another method as a secondary means of escape
- use natural roof openings whenever possible
- cut large hole, if one is required, rather than several small ones
- exercise care in making the opening so amin structural supports are not cut
- work with the wind at back or side, to provide protection to the operators while cutting the roof opening
- guard the opening to prevent personnel from falling into the building
- extend a blunt object through the opening, to break out the ceiling

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

4-10 Ventilation

4-10.3

Ref: pp. 60-65 #107 6th ed
pp. 80-96 #107 5th ed.

TEACHING POINTS

Safety Precautions

The ranking fire officer on the roof should be in constant communication with the chief officer at the scene.

Portable radios are most adaptable to this type of communication.

The officer on the roof responsibility includes:

- insuring that only openings required are made
- coordinating the ventilating crews efforts with the inside attack
- insuring the safety of all ventilating or other personnel on roof

Some of the safety precautions that should be practied include:

- providing a secondary means of escape
- preventing personnel from walking on spongy roofs
- This is usually a sign that structural members have been weakened. (If it is necessary to open a weakened roof, a roof ladder laid on the roof serves to distribute the firefighter's weight over a larger area.)
- securing a lifeline to any firefighter who is to enter a weakened roof area
- protecting personnel from sliding and falling
- exercising caution in working around electric wires and guy wires
- insuring that the person making the openings is standing to the windward side of the cut and wearing the proper protective equipment
- not allowing other persons within range of the axe
- cautioning axe users to beware of overhead obstructions within the range of their axe
- starting power tools on the ground to sinsure operation at the site of the cut at upper areas. It is important that the tool be shut off before hoisting or raising the tool to these upper areas.

INSTRUCTORS NOTES

Ref: Fire Ventilation
Practices #107, IFSTA
6th ed. pp. 1-118

Ref: Essentials of Fire
Fighting #200, IFSTA
pp. 235-248

4-10 Ventilation

4-10.3

Ref:pp. 60-65 #107 6th ed
pp. 80-96 #107 5th ed.

TEACHING POINTS

Safety Precautions

. cautioning all cutting equipment operators to make sure the angle of the cut is not toward their bodies

. being on the lookout for indications of weakening structures or other hazards

. exercising caution, especially when using power tools, not to cut or weaken supporting structural members

. keeping firm footing

Potential Hazards

Large flat or arched roofs covering undivided and unsupported areas present special hazards to firefighters.

Single fire areas greater than 50,000 square feet are not uncommon.

In some buildings open bays 40 by 50 feet with 20-foot or higher ceilings are required for the fabrication and storage of large items.

The roofs of these structures, when supported by unprotecte steelwork, mau be expected to fail within a few minutes when exposed to intense heat.

IN MANY INSTANCES, LESS THAN TEN MINUTES EXPOSURE CAUSES COLLAPSE.

Large unbroken pitched roofs, which are normally used on barns, churches and auditoriums, present peculiar ventilation problems.

Firefighters frequently discover that it is not possible with standard equipment to reach the place where the openin should be made.

In some instances, it is necessary to open this type of roof twice

once high up on the leeward side to provide an escape for the heated gases

and

again lower down to provide an intake for air.

Ceilings under this type of roof are often located so far below the roof that they cannot be reached with the pike pole to open them.

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

4-10 Ventilation

4-10.3

Ref:pp. 65-68 #107 6th ed
pp. 80-96 #107 5th ed.

TEACHING POINTS

Trenching

Trench ventilation sometimes referred to as strip ventilation, is a form of ventilation when properly done, will often prevent the horizontal spread of heat, smoke and fire throughout a large building.

This type of ventilation has been found to be very successful in controlling fires in buildings such as:

schools
apartment houses
motels
rest homes
factories

having long, open, undivided attic areas.

Trenching is done by making a three to four foot wide opening in the roof, then running this cut across the entire width of the building.

Firefighters must remember to open the ceiling below onec they have completed opening the roof.

IT IS IMPERATIVE THAT THE TRENCH LOCATION BE PLANNED AND SUFFICIENT TIME BE ALLOWED TO PERMIT THE COMPLETION OF THE OPENING BEFORE THE FIRE REACHES THE TRENCH.

The opening, when completed, will allow a damper effect to be established, drawing heat and products of combustion out of the opening, preventing a horizontal spread of the fire.

Interior hose lines should be placed in uninvolved areas below the trench cut and directed toward the fire area to in stopping the fire spread. Other streams can be used to protect the roof

Many times will appear at the opening in the roof.

AT NO TIME SHOULD A HOSELINE OR ELEVATED STREAM BE DIRECTED INTO THIS OPENING.

By directing water onto the flames, all of the heat and smoke will be forced back into the building.

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

4-10 Ventilation

4-10.2

Ref: pp. 68-73 #107 6th ed
pp. 80-96 #107 5th ed.

Note: On metal-covered roofs it should be possible to remove an entire section at one time. Pry along the edges pulling screws or nails as necessary, and remove panel from leeward side of roof.

TEACHING POINTS

Opening Roofs

When the requirement to open the roof is recognized and natural openings do not exist or are not adequate to release the accumulated heat and smoke, the officer in charge may order the roof cut open.

The initial opening should be made large enough to do the job.

For example: one 8 by 8 foot hole is equal to four 4 by 4 foot holes.

Make the opening square or rectangular to facilitate repairs being made more easily.

GABLED, HIP AND GAMBREL ROOFS

Tools	Axe, power saw (general purpose blade) pike pole, ladders and lifline
Where	Laterally along ridge, leeward side first, over fire
Construction	Wood and metal. Rafters generally run from eave to ridge. Sheathing placed on top, perpendicular to rafters.
Cut	Parallel to the rafters, or perpendicular to the ridge for approximately three feet. Pull sheathing or plywood with roof covering, using pick of axe or other tools.

FLAT, SLOPED AND MANSARD ROOFS

Tools	Axe, power saw (general purpose blade) pike pole, stripping ladder, ladders and lifeline.
Where	Over seat of fire.
Construction	Wood. Rafters usually run parallel to narrow dimension of the building. Sheathing is placed perpendicular to the rafters or narrow side.
Cut	Two cuts parallel to narrow dimension along rafters (may have to cut covering first). Make third cut perpendicular to narrow side of roof on leeward side. Open with pick of axe, insert stripping ladder or pike pole and roll back

INSTRUCTORS NOTES	TEACHING POINTS
Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118 Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248 __4-10 Ventilation__ 4-10.2 Ref: pp. 68-73 #107 6th ed. pp. 80-96 #107 5th ed.	

__FLAT, SLOPED AND MANSARD ROOFS__ cont.

Cut	sheathing and roof covering. Use butt of pike pole or stripping ladder to remove ceiling.

__METAL DECK__

Tools	Axe, power saw (general purpose blade for up to 18-gauge metal and metal blade for heavier) pike pole, ladders and lifeline.
Where	Over seat of fire
Construction	Metal bar joists usually run parallel to narrow dimensions of building, metal decking is perpendicular to joists or narrow side. Built-up roof is placed over metal panels.
Cut	Two cuts parallel to narrow dimension along joists. Third cut perpendicular to joists on leeward side. Avoid cutting joists if possible. Pry up with pick of axe, breaking the tack welds. Roll back with stripping ladder or pike pole. Remove suspended ceiling below.

__LARGE METAL DECK__

Tools	Same as metal deck
Where	Same as metal deck
Construction	Supporting beams run parallel to the narrow side of the building, and bar joists perpendicular to the beams and narrow side. Sheathing is parallel to the narrow side and beams.
Cut	Two cuts perpendicular to the narrow side and beams, or parallel to bar joists. The third cut is parallel to the narrow side on the leeward side of the opening. Avoid cutting joists, if possible. Pry up with pick of axe, breaking tack welds, and roll back with stripping ladder or pike pole. Remove suspended ceiling below.

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

4-10 Ventilation

4-10.2

Ref: pp. 68-73 #107 6th ed.
pp. 80-96 #107 5th ed.

TEACHING POINTS

CONCRETE

Tools	Air hammer, power saw with concrete blade (if concrete is less than four inches thick)
Where	Over fire area or vertical shaft
Construction	Poured concrete on reinforced concrete beams
Cut	Generally it will not be possible to open roofs of this construction. Ventilate by using existing roof openings, such as elevator or stairwell shafts, ventilators or scuttle holes. DO NOT USE BUILDINGS MECHANICAL VENTILATION SYSTEMS.

GOTHIC OR TRUSSED ROOFS

Tools	Axe, power saw (general purpose blade) pike pole, stripping ladder, ladders and lifeline.
Where	At top of bow or peak over fire, or long narrow cut at top of bow or peak over several rooms.
Construction	Wood or metal. Trusses placed across narrow side of building or multiple bays of trusses. Rafters run perpendicular to trusses. Sheathingrruns parallel to trusses.
Cut	Two cuts perpendicular to trusses or narrow side of building, along rafters.
Make.	Make third cut parallel to trusses on leeward side. Open with pick of axe, insert stripping ladder or pike pole, and roll back sheathing and roof covering. Use butt of pike pole or stripping ladder to remove suspended ceiling if necessary.

INSTRUCTORS NOTES

Ref: Fire Ventilation
Practices #107, IFSTA
6th ed. pp. 1-118

Ref: Essentials of Fire
Fighting #200, IFSTA
pp. 235-248

4-10 Ventilation

4-10.2

Ref. pp. 68-73 # 107 6th ed
pp. 80-96 #107 5th ed.

TEACHING POINTS

TILE/SLATE ROOFS

Tile roofs such as found on Spanish architecture, or slate roofs often found on churches or other large buildings, present special problems in ventilation.

When a tile/slate roof has to be ventilated; use:

. a roof ladder to provide good footing for personnel

. a sledge hammer which can shatter the tiles or slate

. an axe or power saw to cust the sheathing.

CAUTION: Tile/slate roofs carry more weight per surface area than any other roof style and are very susceptible to early roof collapse.

Roofs with this much weight also become "spongy" earlier than one might expect.

Because of this weight factor, ventilation crews must always be sure to coordinate their efforts with attack crews and, especially, warn them of the potential of falling debris.

A "spongy" roof is one that has been weakened by fire.

Indications of a "spongy" roof include sagging under a persons weight and lack of resistance to an axe. (the wood will act punky).

Many modern roofs are "springy"; that is, they will give some when a person walks on them at any time.

CHURCH FIRES

When fighting fire within churches, vertical ventilation becomes almost impossible because of the high, steep roofs that many churches have.

Many times the height of the roof is greater than the length of the roof ladders carried by the fire department.

Often, because of the height of the building and the angle of the roof, aerial ladders must be used.

Even if vertical ventilation is possible, many old churches have a dead air space of 12 to 18 feet between the ridge of the roof and the ceiling below.

It is highly unlikely that the fire department will have a pike pole long enough to remove the ceiling below the roof opening.

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

4-10 Ventilation

4-10.2

Ref. pp. 68-73 #107 6th ed.
pp. 80-96 #107 5th ed.

TEACHING POINTS

CHURCH FIRES

Many old churches have ceilings that are constructed of heavy plaster. During a fire, these ceilings may collapse and injure firefighters below.

Horizontal ventilation may be the only possible way in which ventilation can be accomplished.

Even this will be difficult because many modern churches are built windowless or with very few windows at all..

In older churches, windows may be made of stained glass, which is very costly to replace and may have much sentimental value to the community.

Firefighters should not hestitate to break out stained glass windows IF IT IS THE ONLY WAY TO PROVIDE SOME TYPE OF VENTILATION TO THE STRUCTURE.

It is better to replace the stained glass winows than the entire structure.

Precautions Against Upsetting Established Vertical Ventilation

Firefighters at some time or other may have had the experience of being driven from a building by intense heat and smkoe after action had been taken to ventilate the building.

A condition like this could be very surprising, especially if good sound ventilation practices had been followed.

When vertical ventilation is accomplished, the natural convection of the heated gases creates upward currents that draw the fire and heat in the direction of the upper openin

Fire fighting teams take advantage of the improved visibilit and less contaminated atmosphere to attck the fire at its lowest point, following through to extinguishment, roughly along the same route the smoke is traveling.

If the "stack effect" is interrupted, the heat, smoke, and steam backs up, hampering extinguishment efforts.

INSTRUCTORS NOTES	TEACHING POINTS
Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118	Precautions Against Upsetting Established Vertical Ventilation
Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248	Some common factors that can destroy the effectiveness of ventilation are:
4-10 Ventilation	. improper use of forced ventilation . breaking glass at wrong place or time . improperly directed fire streams
4-10.2	. breaking skylights at wrong place or time
Ref. pp. 74-75 #107 6th ed pp. 80-96 #107 5th ed.	. an explosion . a burn-through . additional openings bewteen the attack team and the upper openings
	Elevated streams are frequently used to cut down sparks and flying brands from a burning building or to reduce the thermal column of heat over a building.
Refer to Handout #16	When elevated streams are projected downward through a ventilation opening or used to reduce the thermal column to a point where ventilation is hindered, they eith destroy or upset the orderly movement of fire gases from the building.
	An upset of this nature can materially effect firefighters who may be working at various levels on floors below.
	Elevated streams that are being operated closely above ventilated openings should be projected SLIGHTLY ABOVE THE HORIZONTAL.
	In this position they will help cool the thermal column and extinguish sparks.
	The movement of the stream may even increase the rate of ventilation.

INSTRUCTORS NOTES

Ref: Fire Ventilation
Practices #107 , IFSTA
6th ed. pp. 1-118

Ref: Essentials of Fire
Fighting #200, IFSTA
pp. 235-248

3-10 Ventilation

3-10.3
3-10.4

Ref: pp. 79-87 6th ed. #107
pp. 99-111 5th ed #107

TEACHING POINTS

Horizontal Ventilation

Thus far, only vertical ventilation has been stressed. Although this method may be fundamentally typical in fire ventilation, vertical ventilation is not the solution to all ventilation problems.

There may be many instances where its application would be impractical or impossible because of conditions and considerations previously discussed. Only prompt and accurate size up based on thorough understanding of the many variables that affect and are affected by ventilation can provide the answer to the following two questions.

. is ventilation required ?

. What method is most appropriate in this instance ?

Horizontal ventilation is a method that may prove to be more effective for a particular situation or it may be used in conjunction with other methods.

In addition to selecting the method of ventilation, a fire officer must determine

HOW

WHEN

AND

WHERE

it will serve its most useful purpose.

Building type, design and occupancy are some of the initial factors that must be considered in determining whether either horizontal or vertical ventilation should be accomplished.

Type and design features that have a bearing on the decision include:

. number and size of wall openings . number of stories

. availability and involvement of exterior fire escapes . exposures

Directly related to these are protective coverings of the openings, the direction in which the openings face, and the wind direction.

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

3-10 Ventilation

3-10.3
3-10.4

Ref: pp. 79-87 #107 6th ed
pp. 99-111 #107 5th ed.

TEACHING POINTS

Horizontal Ventilation

Both personnel and materials must be included in occupancy considerations.

If preapproach information has been made available concerning the status of the people who occupy the structure and if rescue is not required, the next consideration is to determine the presence of hazardous materials or processes that may endanger fire fighting crews.

Structures to which horizontal ventilation is normally applied include:

. residential buildings in which the fire has not involved the attic area

. buildings with windows high up the wall, near the eaves

. the attics of residential buildings that have louvered vents in the walls

. the involved floors of multistoried structures

. buildings with large, unsupported open spaces under the roof, in which the fire is not contained by fire curtains and in which the structure has been weakened by the effects of burning.

CAUTION IF A FIRE HAS BEEN BURNING FOR 20 MINUTES, THE ROOF CAN GENERALLY BE CONSIDERED UNSAFE FOR THE WEIGHT OF A FIREFIGHTER.

Location and Extent of the Fire

Many of the aspects of vertical ventilation may also apply to horizontal ventilation.

A different procedure, however, must sometimes be followed in ventilating

. a room
. a cockloft
. a basement
. a floor
. an attic

The procedure to be followed will be influenced by the location and extent of the fire.

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

3-10 Ventilation

3-10.3
3-10.4

Ref: pp. 79-87 #107 6th ed
pp. 99-111 #107 5th ed.

Refer to Handout #17

Location and Extent of the Fire

Some of the ways by which horizontal extension occurs are as follow:

- through wall openings by direct flame contact or by convected air
- through corridors, halls or passageways by convected air currents, radiation and flame contact
- through open space by radiated heat or by convected air currents
- in all directions by explosion or flash burning of fire gases, inflammable vapors, or dust
- through walls and interior partitions by direct flame contact
- through walls by conduction of heat through beams, pipes, or other objects
- through air conditioning and heating ducts
- through plenums

Breaching Firewalls

During ventilation operations, firefighters must be careful not to breach or make openings in firewalls.

As the ventilation process occurs, heat, smoke, and fire gases travel through openings that may also draw the fire toward the opening because of drafts produced and the availability of oxygen at the opening and the other side of the wall.

Therefore, when a firewall is breached to make a ventilatior opening, there is also the possibility of drawing heat, smok and gases through the firewall and endangering the previuosl protected portions of the building that the firewall was designed to protect.

The potential for flammable fire gases to accumulate on the uninvolved side of the firewall at the roof level is perhaps the most serious.

These gases may accumulate, unknown to the firefighter, until a source of ignition reaches the vapors and ignites them, which may cause either a flashover or backdraft.

INSTRUCTORS NOTES

TEACHING POINTS

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

3-10 Ventilation

3-10.3
3-10.4

Ref: pp. 79-87 #107 6th ed
pp. 99-111 #107 5th ed.

Exposures

Since horizontal ventilation does not normally release heat and smoke directly above the fire, some routing is necessary.

Firefighters, therefore, should be aware of internal exposures as well as external exposures.

The routes by which smoke and heated gases would travel to the exit may be the same corridors and passageways the occupants will be using for evacuation.

Outside exposures include all those previously mentioned in the discussion of vertical ventilation, plus those that are peculiar to horizontal ventilation.

Since horizontal ventilation is accomplished at a point other than at the highest point of the building, there is the constant danger that the rising heated gases will ignite the portion of the structure that they contact when released.

- ignite eaves of adjacent structures
- drawn into windows above their liberation point
- smoke and gases drawn by air conditioners into adjacent buildings.

Weather Conditions

A primary consideration in determining the proper ventilation procedure.

Its direction may be designated as

- windward - the side of the building the wind is striking
- leeward - the opposite side of the building from the windward side.

In some cases horizontal ventilation cannot be accomplished effectively because

- when there is no wind to move the smoke or gases

and

- where the danger of the wind blowing toward an exposure or feeding oxygen to the fire.

INSTRUCTORS NOTES

Ref: Fire Ventilation
Practices #107, IFSTA
6th ed. pp. 1-118

Ref: Essentials of Fire
Fighting #200, IFSTA
pp. 235-248

3-10 Ventilation

3-1.3
3-10.4

Ref: pp. 79-87 #107 6th ed
pp. 99-111 #107 5th ed.

TEACHING POINTS

Humidity

Allowances should be made during a time of high humidity because ventilation is somewhat hindered.

High humidity tends to keep the products of combustion from rising into the atmosphere.

This tends to keep the products of combustion at or near ground level.

Inversions

Temperature inversions are called NIGHT INVERSIONS also affect smoke behavior.

During a night inversion, their is a layer of cool air at and above ground level.

The air temperature increases with height.

The temperature difference might be as much as 25 degrees F. in 250 feet.

Smoke will rise until its temperature matches that of the air and will then extend horizontally.

Using Windows

The correct procedure for ventilating a building horizontally is to

. open the top windows on the LEEWARD side

and, after allowing the superheated gases to escape,

. open the lower windows on the WINDWARD side.

. remove screens, curtains, drapes and blinds from windows to improve circulation.

Breaking Windows

. try before breaking (may be unlocked)

. use flat side of axe or tool while standing to the side of window

. hold handle higher than head of tool to prevent glass sliding down handle

. when working from a ladder use pike pole to break top window first.

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fightinf #200, IFSTA pp. 235-248

3-10 Ventilation

3-10.3
3-10.4

Ref: pp. 79-87 #107 6th ed
pp. 99-111 #107 5th ed.

TEACHING POINTS

Thermoplastic Windows

A current trend in the construction industry is the use of Plexiglass and other thermoplastics in place of glass windows.

LEXAN is an example of a polycarbonate that has seen wide application as a glass substitute.

LEXAN is

250 times stronger than safety glass

30 times stronger than acrylics

and is classified as self-extinguishing.

Ventilating or gaining entry through LEXAN requires the use of c circular saw with a carbide-tipped blade.

Note: it is recommended that a medium toothed blade (approximately 40 teeth) be used as tests have shown it has been found to yield the best results.

If a power saw is not available, entry might be made in one of two other ways.

One is to strike the pane in the center with a sledge hammer. This will not break the pane, but will bow it so it is likely to slip out of the keepers.

Another method is to use the point of a pick-headed axe to score an "X" on the pane.

The pane will usually break along the "X" and the pieces can then be pulled or bent out.

Neither technique will work if the pane has been heated to the point where it becomes somewhat soft or pliable.

Obstructions to Horizontal Ventilation

Buildings that contain a large number of rooms may be very difficult to ventilate horizontally because fo the absence of air circulation between the rooms.

The building may be completely filled with smoke that accumulated over a period of time and the smoke may be filtering through cracks and ventilator openings.

INSTRUCTORS NOTES	TEACHING POINTS
Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118 Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248 3-10 Ventilation 3-10.3 3-10.4	Obstructions to Horizontal Ventilation If ventilation is attempted without a knowledge of the location of the fire, or arrangement of the rooms and partitions in the building, uninvolved sections of the building may be jeopardized. Stacks of stored material may obstruct horizontal ventilation. Precautions Against Upsetting Established Horizontal Ventilation
Ref: pp. 79-87 #107 6th ed. pp. 99-111 #107 5th ed.	Personnel should also be careful not to block or close openings that channel fresh air into the area that is being ventilated. Established ventilation may also be upset if additional openings are made that rechannel air currents that are supposed to be ventilating the area.
Refer to Handout #18	Other hindrances of good horizontal ventilation are: . improper use of forced ventilation . improperly directed fire streams . improper placement of salvaged contents with salvage covers covering items and obstructing air currents.
4-10 Ventilation 4-10.5 4-10.6	Situations requiring Forced Ventilation There is no set rule for determining just when to use forced ventilation other than "when necessary for the removal of an undesirable atmosphere." Some of the situations which indicate the need for forced ventilation are listed below: . When the type of construction is unsuitable for natural ventilation because of the lack of vertical shafts or horizontal exterior openings. . [illegible] . When fire is below ground level in basements or below deck on marine craft where it is difficult to gain . entrance . When there is no fire and it is necessary to remove undesirable atmospheres from areas such as tunnels, buildings, basements and other enclosures.

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

4-10 Ventilation

4-10.5
4-10.6

Ref: pp. 91-118 #107 6th ed.
pp. 113-115 #107 5th ed.

Refer to Handout #19

TEACHING POINTS

Situations Requiring Forced Ventilation

. To relay smoke through buildings of large area.

Basements frequently have inadequate ventilation because of

. lack of windows

. weather conditions

. tight construction

and

protection against intruders.

Ventilation in basements and subbasements is normally difficult, presenting problems that are unique to this type of structure.

In order for mechanical ventilation to be successful, the following tasks must be accomplished:

. Start ventilation as soon as the hoselines are attacking the fire.

. Place the ejector at an outside opening that is closest to the fire.

. Place the ejector as high as possible, for maximum effectiveness.

. Use the wind to your advantage to help the smoke ejector either push or pull out the heat and smoke.

. Place the ejector at the proper distance from the opening to prevent recirculation of the smoke.

. Remove items such as draperies, which might interfere with the airflow out of the ejector, from around the [illegible] ejector.

. Use any available means to prevent "churning".

. Provide and maintain unobstructed replacement-air opening.

INSTRUCTORS NOTES

Ref: Fire Ventilation
Practices #107, IFSTA
6th ed. pp. 1-118

Ref: Essentials of Fire
Fighting #200, IFSTA
pp. 235-248

4-10 Ventilation

4-10.5
4-10.6

Ref: pp. 91-118 #107 6th ed
pp. 113-115 #107 5th ed.

TEACHING POINTS

Some Advantages of Forced Ventilation

The value of mechanical ventilation may be further realized when in order to protect human life it becomes necessary to rapidly rid premises or areas of an undesirable atmosphere.

Some of the reasons for employing mechanical or forced ventilation are indicated in the following list:

- It insures more positive control of air movement.
- It supplements natural ventilation.
- It speeds the removal of contaminants, facilitating more rapid rescue under safe conditions.
- It may be used where other methods fail.
- It reduces smoke damage.
- It promotes good public relations

Some Disadvantages of Forced Ventilation

If mechanical or forced ventilation is misapplied or uncontrolled, it can cause a great deal of harm.'

Some of the disadvantages of forced ventilation are indicated in the following list:

- It can move fire along with the smoke and extent it to lateral areas.
- It can introduce air in such great volumes that it can be the cause of fire spreading.
- It is dependent upon power, the interruption of which renders it ineffective.
- It requires special equipment, and additional personnel.

Forced Ventilation Equipment

If natural or vertical ventilation is even partially unsatisfactory, mechanical ventilation should be employed.

By using smoke ejectors to pull products of combustion away from occupants and their means of egress, an avenue of escape or rescue is provided.

INSTRUCTORS NOTES

REF: Fire Ventilation
Practices #107, IFSTA
6th ed. pp. 1-118

Ref: Essentials of Fire
Fighting #200, IFSTA
pp. 235-248

4-10 Ventilation

4-10.5
4-10.6

Ref: pp. 91-118 #107 6th ec
pp. 113-115 #107 5th ed.

TEACHING POINTS

Forced Ventilation Equipment

- Use good equipment. Be sure to use a large enough ejector, or enough ejectors to perform the necessary task.
- Provide proper training in technique to acquire maximum benefit from the equipment.
- Practice good pre-fire planning. Know proper placement of equipment under any condition.
- Plan so equipment, training, methods and tactics will work to accomplish the desired results with no time wasted.

Smoke ejectors perform two primary functions:

1. They exhaust or pull the initial heat and smoke from a burning building

and

2. once the ejection action has started and the smoke becoms thin and less buoyant, they can also be used to blow the smoke from the building.

NOTE: A blowing ejector is also effective in eliminating heavier than air gases.

Eight Rules For Successful Smoke Ejection By Means Of Mechanical Horizontal Ventilation

1. Place exhausting smoke ejector in outside opening nearest source of smoke.
   - Ejecstor should be placed to exhaust in the same directio as the natural wind.
   - Place several ejectors so they push or blow products of combustion to exhausting units positioned in outside openings.
   - The objective is ti eliminate smoke, and the shortest path is usually the best.
2. During the early stages of the fire, most of the heat, smoke and congested fumes rise and accumulate near the ceiling.
   - Place the exhausting ejectors high for maximum effectiven in clearing smoke and providing visibility.

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

4-10 Ventilation

4-10.5
4-10.6

Ref: pp. 91-118 #107 6th ed
pp. 113-115 #107 5th ed.

TEACHING POINTS

Eight Rules For Successful Smoke Ejection By Means Of Mechanical Horizontal Ventilation

- COOL FRESH AIR WILL COME IN BY ITSELF WHEN THE HEAT AND SMOKE ARE REMOVED.

3. Check the direction of the wind and use it to push or blow the products of combustion into an exhausting smoke ejector.

- When using both exhausting and blowing ejectors;
  a. first clear the area from the windward side in the direction of the exhausting smoke ejector
  b. then move the blowing smoke ejectors towrad the exhausting ejector, keeping the circulation line as straight as possible
  c. the venturi action of the straight line circulation will suck most of the smoke from corners.

- If a smoke ejector must be directed into the wind, ANGLE IT so expelled contaminants cannot reenter the building through nearby openings.

4. Air follows the path of least resistance.

- If air is allowed to recirculate around the sides of the smoke ejector and in and out of nearby openings, it causes a "churning" action that reduces efficiency.

- To prevent churning air, cover the area around the unit with salvage covers or other material.

- Fasten in place with a spring-loaded rod or similar device.

- Ideally, the entire opening, with theexception of the area occupied by the smoke ejector should be covered to attain maximum operating efficiency.

5. Establish desired draft path and keep the airflow in as straight a line as possible.

- Every corner causes turbulence and decreases efficiency.

- Avoid opening windows or doors near the exhausting smoke ejector unless opening them definitely increases circulation.

INSTRUCTORS NOTES

Ref: Fire Ventilation
Practices #107, IFSTA
6th ed. pp. 1-118

Ref: Essentials of Fire
Fighting #200, IFSTA
pp. 235-248

4-10 Ventilation

4-10.5
4-10.6

Ref: pp. 91-118 #107 6th ed
pp. 113-115 #107 5th ed.

TEACHING POINTS

Eight Rules For Successful Smoke Ejection By Means Of Mechanical Horizontal Ventilation

6. Remove all obstacles to air flow.

- Even a window screen will cut effective exhaust by half.
- Avoid blockage of the intake side of the smoke ejector by:

  a. debris

  b. curtains

  c. drapes

  or anything that can decrease the amount of intake air.
- DO NOT ALLOW THE SMOKE EJECTOR TO BLOW DIRECTLY AGAINST A WALL OR DOOR.

7. Have smoke ejectors ready to use when hoselines are in position, and have a CHARGED LINE at hand when actually placing the ejectors.

- . Be sure they are placed so that they do not blow into the building.
- THEY MUST PULL THE SMOKE OUT.

8. When the smoke begins to dissipate, speed up the clearing action with a blowing smoke ejector.

- Place an exhausting smoke ejector on the LEE side of the room or building, where it can pull out the remaining smoke and fumes.
- Place the blowing ejector in an outside opening on the WINDWARD side, where it will admit fresh, clean air.
- Results are usually most satisfactory when the blowing ejector is located in the lower part of the window or door.
- In residences and smaller buildings use several blowing ejectors at outside openings or suitable windows in the lowest floor or basement.
- Close all openings on the lower floor and cover the area around the ejectors to create a "pressure-type" circulatic to force smoke or odors out of air conditioning or heating ducts and other concealed spaces.

INSTRUCTORS NOTES	TEACHING POINTS
Ref: Fire Ventilation Practices #107 6th ed IFSTA pp. 1-118	. An exhausting ejector on the floor above will carry off disturbed smoke.
Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248	. A blowing ejector at the bottom of a closet will blow in fresh, clean air and force out smoke and odors through the top of the door opening.
4-10 Ventilation	Placement of Smoke Ejectors
4-10.5 4-10.6	Smoke ejectors function most effectively when they are positioned several feet inside a door.
	This creates a venturi effect in the doorway.
Ref: pp. 91-118 #107 6th ed pp. 113-115 #107 5th ed.	The following guidelines should be used only as an aid in determining the correct placement of ejectors, based on the sizes of the door and the ejector.
Refer to Handout #20	. 16-inch ejector exhausting through a 36-inch door should be positioned 6 to 8 feet from opening.
	. 20-inch ejector exhausting through a 48-inch door should be positioned 6 to 8 feet from opening.
	. 24-inch ejector exhausting through a 48- to 60-inch door should be positioned 6 to 10 feet from opening.
	. In large door openings, place ejector slightly further back or use multiple ejectors.
Refer to Handout #21	Positioned in this manner the ejector not only moves air passing through the propellor, but also draws air into the ai air stream on the discharge side.
	Efficiency increases by 20 to 100 percent of rated capacity.
Refer to Handout #21	Actual increase varies according to the size of the smoke ejector, the size of the door opening through which it is exhausting, and the size of the opening providing replacement or make-up air.
Refer to Handout #22	Remember, the venturi principle is most effective; however, results can be controlled only if the smoke ejector is positioned inside the are to be cleared and the make-up air channeled to that ejector.

INSTRUCTORS NOTES	TEACHING POINTS
Ref: Fire Ventilation Practices #107, IFSTA pp. 1-118 6th ed.	Adequate replacement air is of primary importance in achieving good smoke ejection.
Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248	Inadequate replacement air impairs efficiency of the smoke ejector operation.
4-10 Ventilation	The opening for replacement air should be equal to or larger than the opening for the exhaust.
4-10.5 4-10.6	For example: When exhausting through a common 30 by 84-inch door, the opening for replacement air should also be at least 30 by 84-inches or larger.
Ref: 91-118 #107 6th ed. pp. 113-115 #107 5th ed.	A combination of windows and other smaller openings may be used to achieve the correct area.
	Undersized replacement air openings can result in negative pressure, which can overload the smoke ejector motor and cut down efficiency.
	Standard Placement Methods
	When partitions or other obstructions prevent proper placement of a smoke ejector to create a venturi effect, standard placement methods must be used.
	DOOR PLACEMENT
	Hook the ejector in a doorway, as high as possible, and tilt unit toward the ceiling to attract the greatest volume of smoke.
Refer to Handouts # 23-24	To change the pulling action to blowing action, reverse direction of the smoke ejector.
	For maximum ejection, cover the area around the unit with salvage covers or other material and fasten in place with a spring-loaded rod or similar device.
	HALL OR ARCHWAY PLACEMENT
Refer to Handout #23	When the entrance to an area is an open archway, or when doorways are exceptionally wide, place an extension ladder across the opening and extend it until it is wedged tightly between the opposite corners of the opening (an attic ladder might work well for this.)
	The diagonal position of the ladder provides a good support for the smoke ejector and allows room for traffic to pass through the archway.

INSTRUCTORS NOTES

Ref: Fire Ventilation
Practices #107, IFSTA
6th ed. pp. 1-118

Ref: Essentials of Fire
Fighting #200, IFSTA
pp. 235-248

4-10 Ventilation

4-10.5
4-10.6

Ref: pp. 91-118 #107 6th ed
pp. 113-115 #107 5th ed.

Refer to Handout #23

Refer to Handout #23

TEACHING POINTS

HALL OR ARCHWAY PLACEMENT

Determine the best direction for air flow and hang the unit from the top rung of the ladder, as close to the ceiling as possible.

Run the electtrical cord down the ladder rungs to keep it safely out of traffic.

FLOOR-OPENING PLACEMENT

When smoke, heat or congested fumes are trapped in a windowless area underground, it is necessary to make an opening for their release.

Select and opening - such as a door - above grade through which to channel smoke. (An outside door is best.)

Cut a hole in the floor behind this opening.

Place a straight ladder flat across the hole in the floor.

Use a pike pole to prop another ladder over the first ladder.

The two ladders will form a horizontal V with the large end extending through the doorway.

Raise the second ladder to the height that gives the best angle and position for smoke ejecting.

Cover the top and sides of the framework with with a tarp, being very careful to tuck the tarp under the end and sides of the ladder on the floor so it is held in place and away from the hole and ejector.

STAIRWELL INSTALLATION

Place an appropriately sized ladder on stair step, keeping it to one side so traffic can move past.

Brace against wall at slight angle.

Put hanger hooks over the lesser rung at a height that will enable the ejector to pull smoke from the lower ceiling.

INSTRUCTORS NOTES

Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118

Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248

4-10 Ventilation

4-10.5
4-10.6

Ref: pp. 91-118 #107 6th ed
pp. 113-115 #107 5th ed.

Refer to Handout #24

Refer to Handout #24

TEACHING POINTS

A-FRAME INSTALLATION OR STEP LADDER HANG

The A-frame, made from two ladders or a stepladder, provides sufficient support for a complete bank of units.

Steady the installation by footing the heels of one of the ladders with a pike pole or piece of lumber lashed across the heels to the bottom rung.

After checking to see that the entire assembly is firmly set, hook ejectors to ladder rungs with hanger units.

Refer to Handout #24

WINDOW PLACEMENTS

Double-Hung Window

. Raise lower window.

. Place unit on windowsill, aim away from exposures, and pull window down onto handles.

. Secure both hooks of hanger unit into bottom rail of the window.

. Wrap cable of hooks around handle to obtain length that will hold smoke ejector securely on lower rail of window.

. Stuff opening with pillows or cover with blankets or salvage covers to prevent churning.

Casement Windows

. Roll window open and place one hanger hook over top window hinge.

. Fasten the second hook into the mullion of the window to steady the unit.

. Rest unit on metal edge of window to prevent damage.

LADDER PLACEMENT FOR WINDOW

Ladders can be set up either inside or outside the building.

Place the ladder against the wall, determine the best rung for the ejector and hang the hanger hook over the rung.

INSTRUCTORS NOTES

Ref: Fire Ventilation
Practices #107, IFSTA
6th ed. pp. 1-118

Ref: Essentials of Fire
Fighting #200, IFSTA
pp. 2350248

4-10 Ventilation

4-10.5
4-10.6

Ref: pp. 91-118
#107 6th ed.
pp. 113-115 #107 5th ed.

Refer to Handout #25

TEACHING POINTS

Window Well Placement

Window well placement is ordinarily set up outside to pull smoke and fumes from a basement.

Since the ejector rests on or near the ground, a larger unit (24-inch) can be used for greater blowing or pulling power. Refer to Handout #25

It is usually necessary to break the glass in the window.

Cover the remaining area around the unit with a tarp or similar material to increase pulling power of the unit.

The shape and location of the window might require tilting the units in order to get the closest proper angle to the window itself.

Scuttle Hanger Placement

This specialized and highly efficient method of using the unit pulls smoke out of attics, manholes or similar types of openings.

Suspen the smoke ejector firmly into the scuttle hole opening with a pike pole and hangers.

If a pole is not immediately available, use the alternative method of suspension as shown by the dotted lines in the handout.

Heavier-Than-Air Gases

Because cooled or unheated heavier-than-air gases concentrate in low points of a building, especially basements, pits and tunnels, they can be removed only with mechanical ventilation.

This is accomplished by following the rules for normal mechanical ventilation with the exception of Rule No. 2.

Heavy gases accumulate at or near the floor; therfore, the ejector must be placed as low as possible in the opening.

Position several ejectors to push gases to an exhausting unit, which in turn will expell gas to the outside atmosphere.

When a heavy gas is found below grade, create as forceful a circulation as is possible.

INSTRUCTORS NOTES

Ref: Fire Ventilation
Practies #107, IFSTA
6th ed. pp. 1-118

Ref: Essentials of Fire
Fighting #200, IFSTA
pp. 235-248

4-10 Ventilation

4-10.5
4-10.6

Ref: 91-118 #107 6th ed.
pp. 113-115 #107 5th ed.

TEACHING POINTS

Heavier-Than-Air Gases

Use both pulling and blowing actions to dilute heavy gas, as much as possible, when it reaches the atmosphere.

Since many heavy gases are combustible, all sources of ignition inside and outside the building must be eliminated.

ALWAYS USE SMOKE EJECTORS WITH EXPLOSION-PROOF MOTORS.

ALL FIREFIGHTERS WORKING BELOW GRADE MUST BE WEARING POSITIVE PRESSURE SELF CONTAINED BREATHING APPARATUS

SAFETY PRECAUTIONS

- Pick up ejector only by the handles or hangers.
- Prevent curtains and drapes from covering intake of a smoke ejector.
- When blowing smoke ejector is on the floor, supervise traffic in area. The suction action of the ejector can draw loose clothing into the unit. Keep children away from any operating unit.
- Do not operate smoke ejectors too long in severely cold weather, especially if the fire has affected the heating system. Prolonged operation can cause water pipes to freeze.
- Prevent the blowing about of papers, loose material, debris or dirt, which can add to overall damage or inconvenience.
- In combustible atmospheres use smoke ejectors with explosion-proof motors ONLY.
- Smoke ejectors with explosion-proof motors and switches can be started and stopped safely in combustible atmospheres.
- Place the smoke ejector in position with the switch in the OFF position.
- Make all necessary electrical connections (even in the combustible area).
- Turn the switch ON. Since no circuit is complete with the switch in the OFF position, there can be no arc or ignition of the vapors. When the switch is turned on, the starting arc is contained inside the motor.

INSTRUCTORS NOTES	TEACHING POINTS
Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp. 1-118 Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248 **4-10 Ventilation** 4-10.5 4-10.6	**SAFETY PRECAUTIONS** . Prevent heavier-than-air gases from entering other low areas where damage or injury could occur. Drive gas forcefully upward into the atmosphere, where it is diluted into a harmless state. . A smoke ejector should never be operated or adjusted while guards are removed from the unit. . All electrical connections should be grounded.
Ref: pp. 91-118 #107 6th ed pp. 113-115 #107 5th ed.	**The Application of Water Fog as an aid to Ventilation** Application of water as a fog stream posses great merit for the control of certain types of fires. The speed with which a given volume of water will absorb heat is in proportion to the amount of water surface that is exposed, and, likwise, its ability to attract or collect the carbon, tar, and ash particles is also increased. As these water particles absorb heat from the heated area, the water is converted into steam, and the expansion that takes place may materially aid ventilation.
Refer to Handout #26	**Using Water Fog to Expel Smoke and Gas** A fog nozzle stream directed through the opening with a 60 degree angle fog pattern covering 85 to 90 percent of the opening has been found to provide the best results for ventilation. The nozzle should be about two feet from the opening. Larger openings permit greater air flow, so a door might sometimes be more beneficial than a window. Whatever the size of the opening, wide angle streams should not be used, because when the water path comes close to a right angle to the air path much of the energy that moves the air is lost. There are three drawbacks to the use of fog streams in forced ventilation:

INSTRUCTORS NOTES	TEACHING POINTS
Ref: Fire Ventilation Practices #107, IFSTA 6th ed. pp1-118 Ref: Essentials of Fire Fighting #200, IFSTA pp. 235-248 4-10 Ventilation 4-10.5 4-10.6 Ref: pp.91-118 #107 6th ed pp. 113-115 #107 5th ed.	Using Water Fog to Expel Smoke and Gas 1. There will be an increase in the amount of water damage within the structure. 2. There will be a drain on the available water supply. 3. In climates subject to freezing temperatures there will be an increase in the problem of ice in the area surrounding the building.

UNIT QUIZ

The following are some of the advantages that may be obtained through the process of ventilation. CIRCLE THE MOST APPROPRIATE ANSWER.

1. Proper ventilation simplifies and expedites the resue of victims by removing _________ and _________

   a. obstacles, fire
   b. smoke, gases
   c. water, air

2. The removal of smoke, gases and heat from a building permits firefighters to more rapidly _________ the fire and proceed wiIth its extinguishment.

   a. control
   b. identify type of
   c. locate

3. When sufficiont heat is confined in an area, the temperatures of combustible materials rise to _________ .

   a. their ignition points
   b. exploding flames
   c. an unsafe level

4. Materials mentioned in the preceding question will not ignite unless sufficient _________ is available to support combustion.

   a. fire
   b. heated gas
   c. oxygen

5. Oxygen, then, is all that is needed to change the overheated area into an inferno. This sudden ignition is often referred to as a _________ .

   a. heat explosion
   b. backdraft
   c. superheated gas inferno

66.As heat, smoke and heated gases are trapped at the _________ point in a confined area, they begin to accumulate, bank down and spread _________ to involve other areas of the structure.

   a. highest, laterally
   b. widest, down
   c. highest, down

7. The ________ effect is the vertical, natural air movement throughout the building.

   a. stack
   b. breeze
   c. chimney

8. A roof that is spongy or springy indicates that the roof supports have been ________ .

   a. ventilated
   b. water logged
   c. weakened

9. The magnitude of the stack effect is determined by differences in ________ and the ________ between the air inside and outside the building.

   a. temperature, humidity
   b. smoke, heat
   c. temperture, densities

10. If the ventilation opening is made in a location other than directly over the fire, it may ________ the fire.

   a. spread
   b. localize
   c. stop

The following questions are in reference to the procedure for opening roofs. FILL IN THE BLANKS: T FOR TRUE F FOR FALSE

11. ____ Locate roof supports by sounding with the axe.

12. ____ Cut the wood decking across the joist.

13. ____ The flat roof does not usually have a slight slope toward the rear of the building.

14. ____ The procedure for opening a pitched roof is very different from that for a flat roof

15. ____ Scuttle hatches provide an adequate opening for ventilation purposes.

16. ____ If skylights contain wired glass they are more easily opened by removing the frames.

17. ____ A ventilation hole should not be cut through the trussless arch construction because of possible collapse.

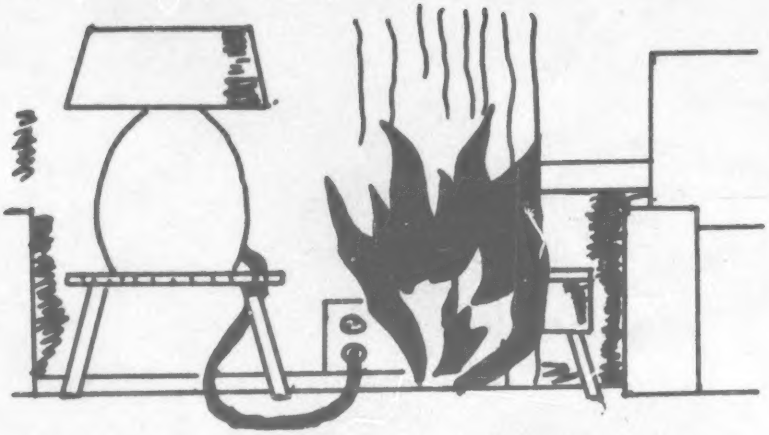
18. ____ Between the rafters it will sound dull and solid.

19. ____ One form of arched roof construction is the bow-string truss. This construction often has enclosed roof space and contributes to the spread of fire.

20. ____ Stairway doors may also be used for ventilation.

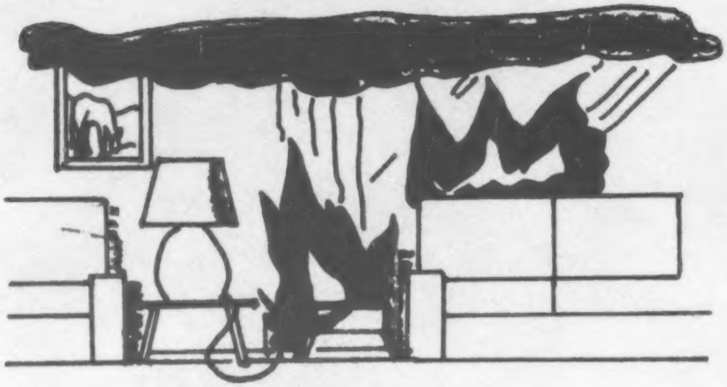
ANSWER KEY

1. b
2. c
3. a
4. c
5. b
6. a
7. a
8. c
9. c
10. a
11. T
12. F
13. F
14. F
15. F
16. T
17. F
18. F
19. T
20. T



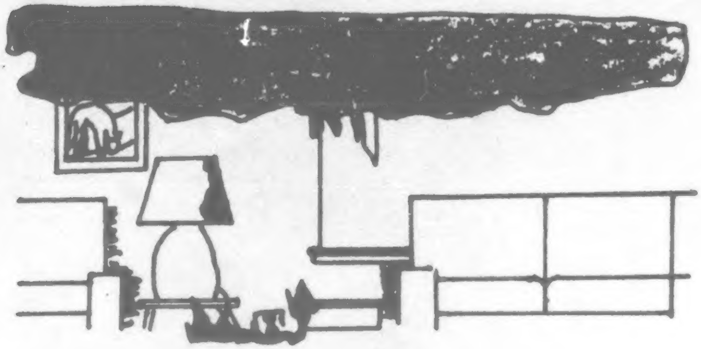
INCIPIENT PHASE

- Slightly over 100 degrees F. (27 degrees C) in the room
- Rising hot gases
- Room approximately 20% oxygen



FREE BURNING PHASE

- Approximately 1300 degrees F. (705 degrees C.)
- Heat accumulates at upper areas
- Reduced oxygen supply

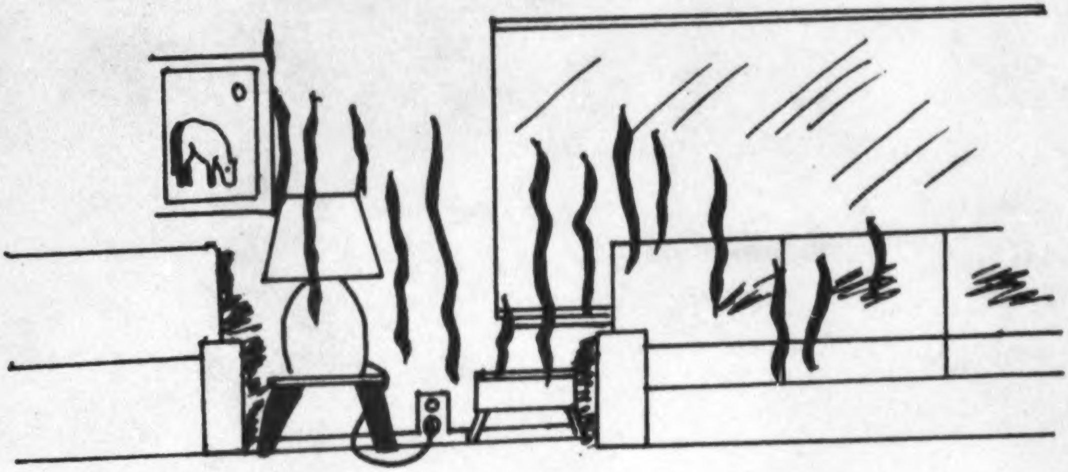


SMOULDERING PHASE

- Oxygen below 15%
- Temperature throughout is high
- High CO and carbon concentration

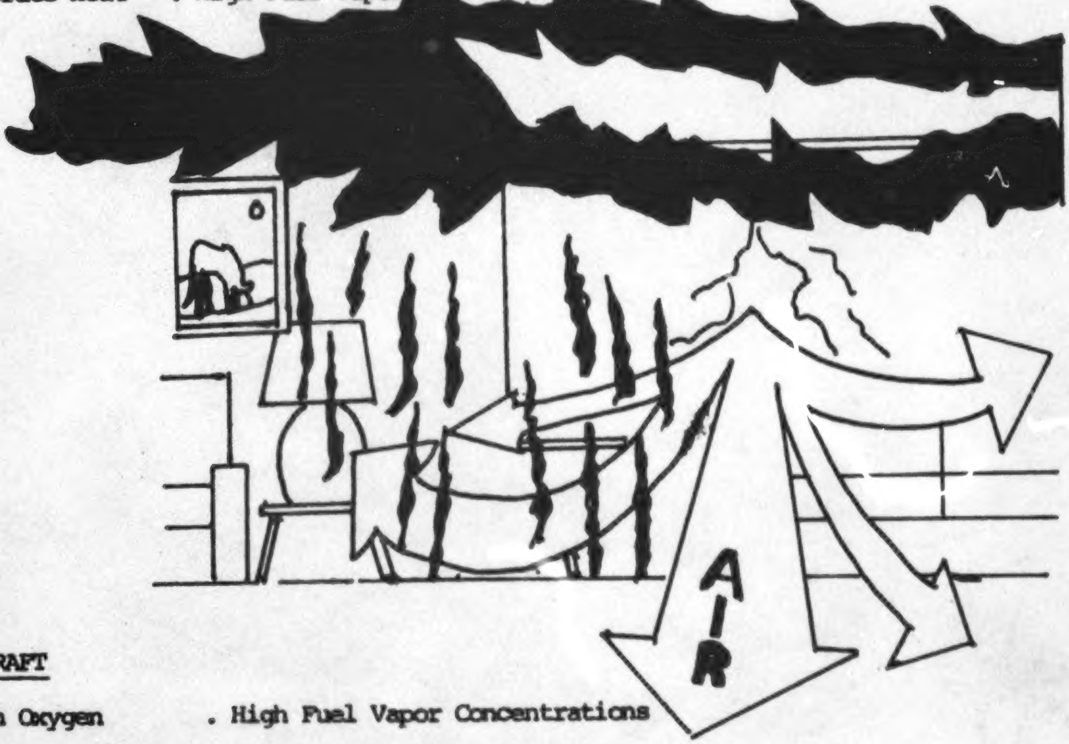
OXYGEN DEFICIENCY

Percentage of Oxygen in the Atmosphere	Symptom
17	Reduced muscular coordination increased respiratory rate
15	Free burning ceases
12	Dizziness, headache, quick fatigue
9	Unconsciousness
6	Death within a few minutes from respiratory and concurrent heart failure



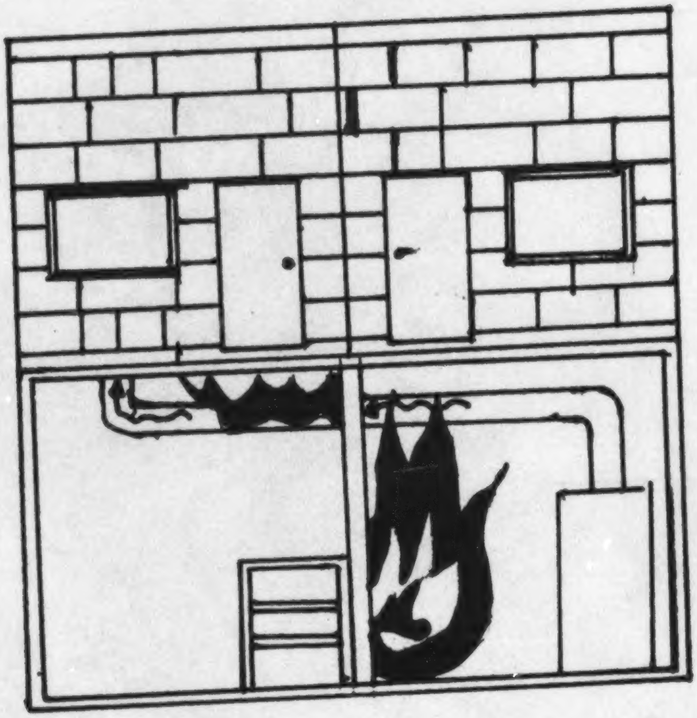
BACKDRAFT POTENTIAL

- . Low Oxygen
- . Moderate Heat
- . Smouldering Fire
- . High Fuel Vapor Concentrations



BACKDRAFT

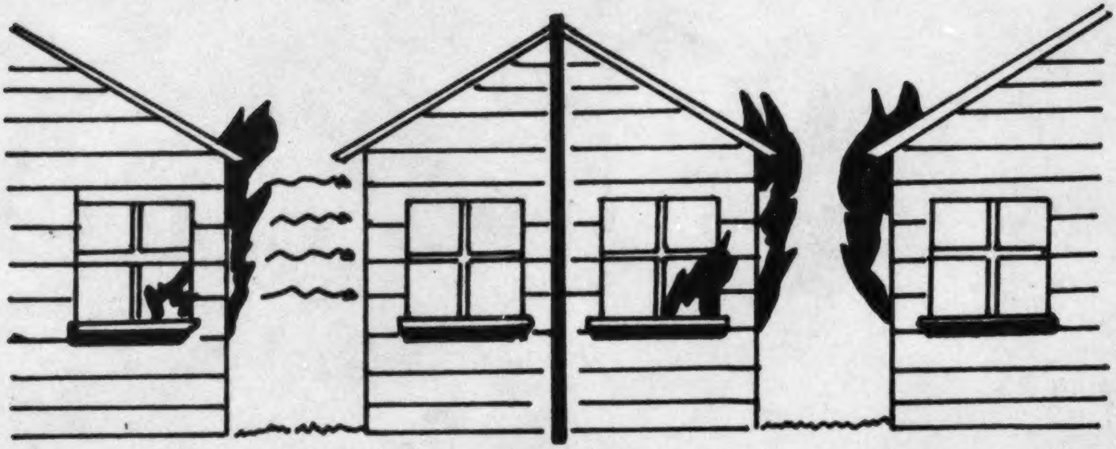
- . High Oxygen
- . Moderate Heat
- . Smouldering Fire
- . High Fuel Vapor Concentrations
- . Introduction of Oxygen Causes Fire of Exposive Force



HEAT TRANSFER BY CONDUCTION

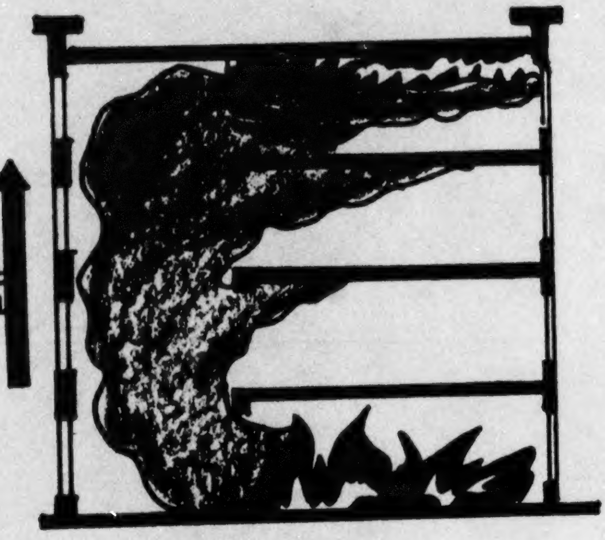
Heat can be conducted through walls or floors by metal pipes igniting adjacent combustibles.

HEAT TRANSFER BY RADIATION

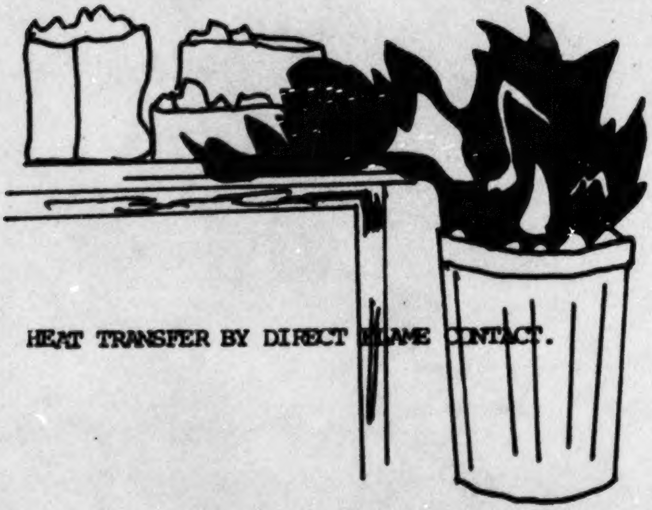


Heat waves can radiate
sufficient energy to
cause ignition.

HEAT TRANSFER BY CONVECTION

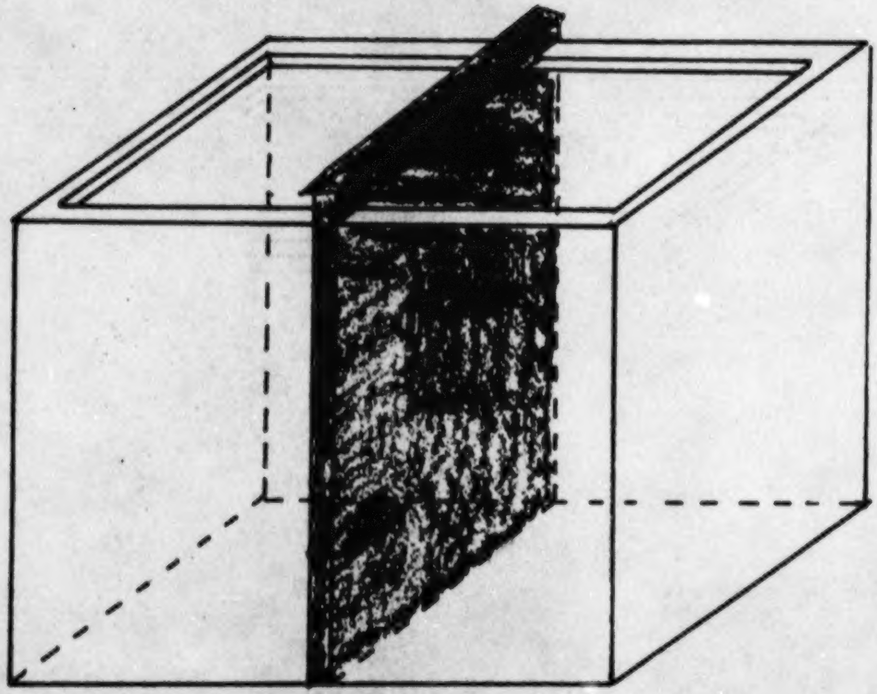


Upward travel of hot gases, as wit an open stairwell

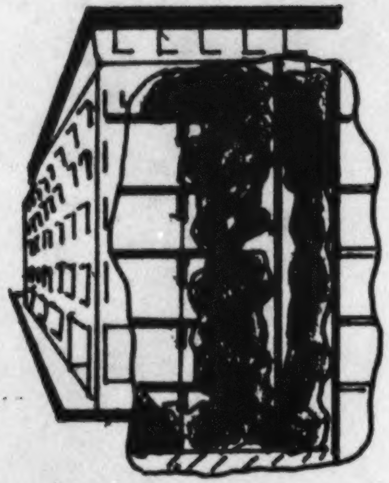


HEAT TRANSFER BY DIRECT FLAME CONTACT.

FIRE WALL

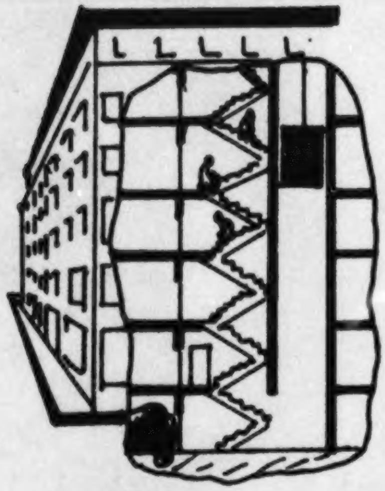


A well-constructed fire wall prevents the spread of fire from one part of a building to another. The fire wall's integrity must not be broken by ductwork, doors or similar openings.



STAIRWELL DOORS OPEN

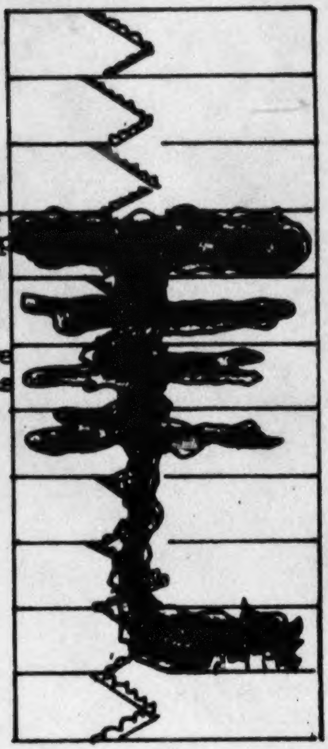
Open shafts create upward drafts causing evacuation problems.



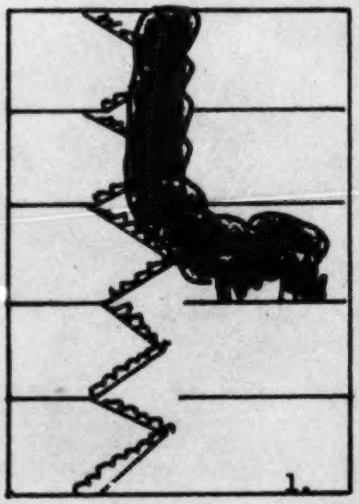
STAIRWELL DOORS CLOSED

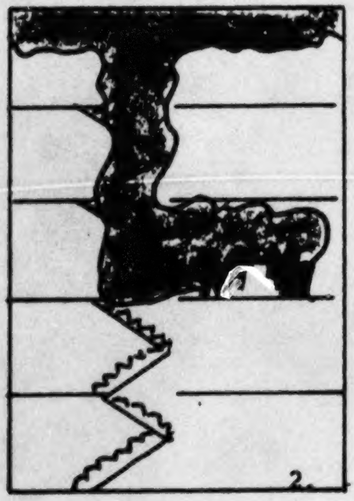
STRATIFICATION OF SMOKE AND FIRE GASES

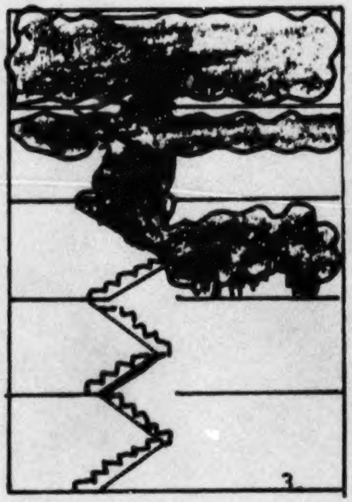
In very tall buildings, mushrooming has a variant: The smoke and gases cool on their journey upward and layer themselves before reaching the topmost solid barrier. The smoke generally serves as a "lid" for other products of combustion. The level above the fire at which this can occur varies with a number of factors including fuel, intensity and size of fire, types of smoke channels, height of the building, and weather.



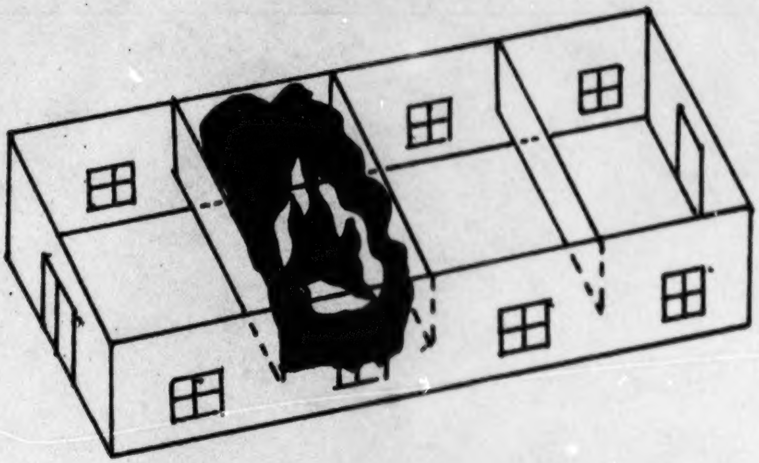
When smoke and gases cannot escape vertically, they fill all available space from the top, down. Opening at the top will be necessary to prevent either backdraft or flashover if the mushrooming is advanced.



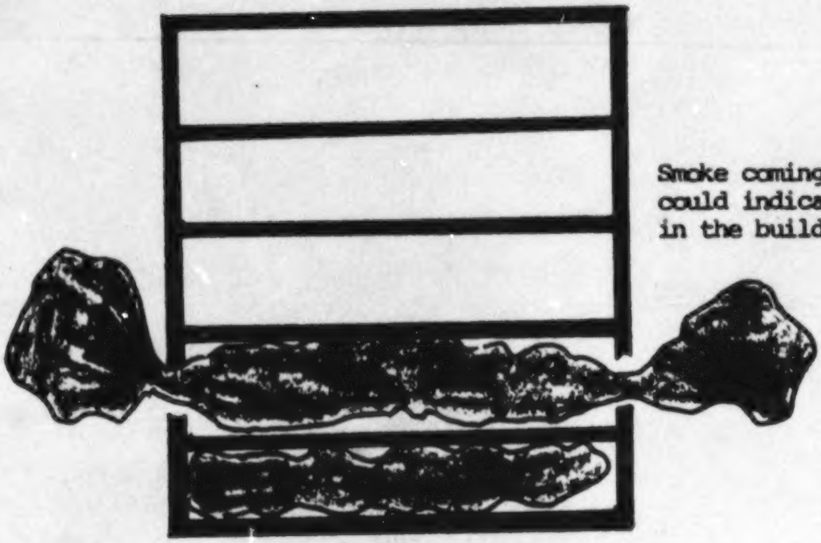




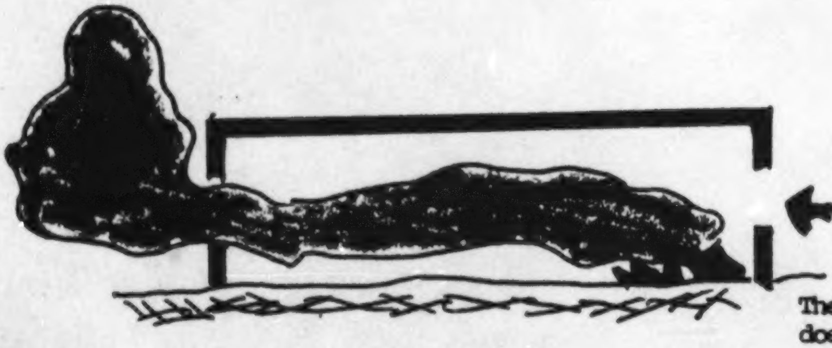
CURTAIN BOARDS



Curtain boards are extended from the ceiling of a large open space to confine heat and smoke.



Smoke coming from a lower story could indicate that openings higher in the building are blocked



The place where smoke appears does not necessarily indicate the location of the fire. Wind currents, building layout and closed doors can affect smoke travel.

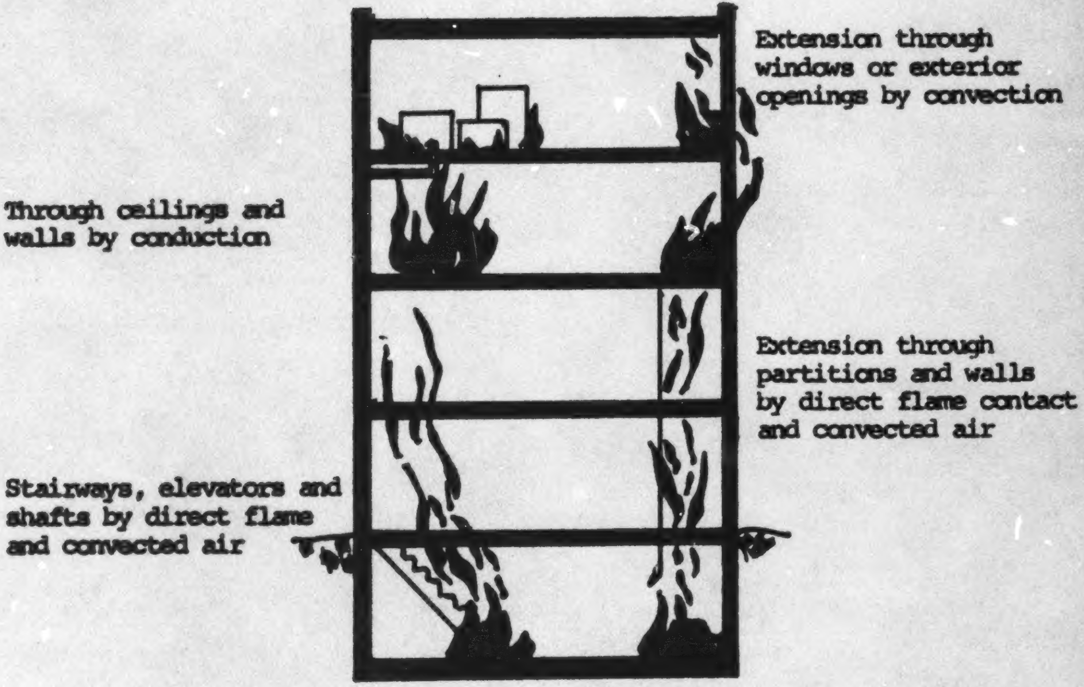
VENTILATION PROCEDURES

HAZARDS INVOLVED IN VENTILATION	POSSIBLE CONSEQUENCES	APPROVED PRACTICES
Opening Below Fire	Backdraft No ventilation No value	Open above fire
Opening Too Soon	Lines not laid Fire gets away Increased loss Additional work time Additional life hazard	Lay and charge lines simultaneously
Opening Wrong Place	No ventilation Backdraft Spread fire to area not involved Increased loss Additional work time Additional life hazard Adverse criticism	Have previous knowledge of building Open over vertical shafts Know contents Know hallways and partitions
Opening Into Blind Attic	No ventilation Backdraft Loss of time Additional loss Additional life hazard	Have previous knowledge of building Use pike pole to open ceiling below
Insufficient Opening	Ineffective ventilation Backdraft Loss of time Additional loss Additional life hazard	Open large enough hole in first place Know size and location of areas below
Involvement of Exposures	Spread of fire Increased loss Additional work time Additional life hazard	Know surrounding buildings in advance Know horizontal openings Know roof structures Watch wind direction and velocity Have lines covering exposures Know heat and gases

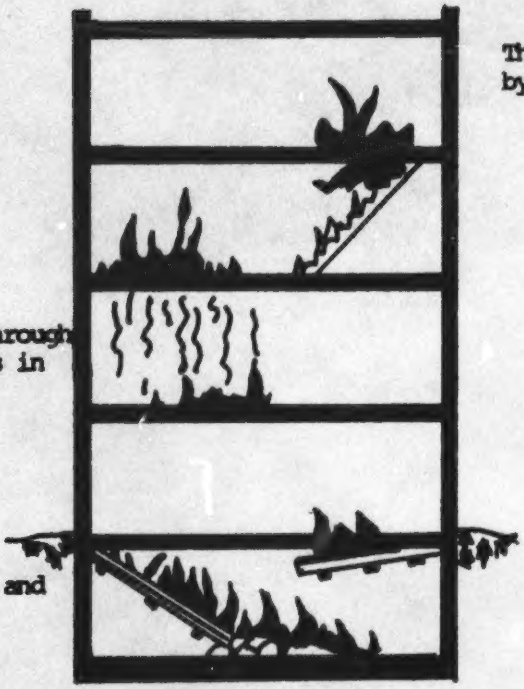
VENTILATION PROCEDURES

HAZARDS INVOLVED IN VENTILATION	POSSIBLE CONSEQUENCES	APPROVED PRACTICE
Life Hazards to firefighters	Roof collapse Explosions below Bad smoke and gas conditions Escape difficult in emergency	Paint top 18 inches of ladders (reflective white) Know building construction in advance If doubtful, lay aldder flat on roof
	Injury from other's use of tools	Delay lower openings for ventilation above Know contents of buildings Cut from windward side of opening Place escape rope Two persons cutting work from diagonally opposite corners of cut Have charged line at opening
Ventilation delayed	Backdrafts Roof unsafe Entire building involved Excessive losses Increased life hazard	Prompt decisions Prompt action
Public Criticism	Hurts reputation of department Lowers morale of department Lessens public support Pro,otes political interference Lowers department efficiency	Know buildings in advance Know principles of ventilation Know proper method of ventilation Use judgement Do a workmanlike job Explain department practices to public Explain reasons for ventilation Admit your mistakes Have department trained and disciplined Have knowledge of smoke and gases

UPWARD VERTICAL EXTENSION


Extension through windows or exterior openings by convection
Through ceilings and walls by conduction
Extension through partitions and walls by direct flame contact and convected air
Stairways, elevators and shafts by direct flame and convected air

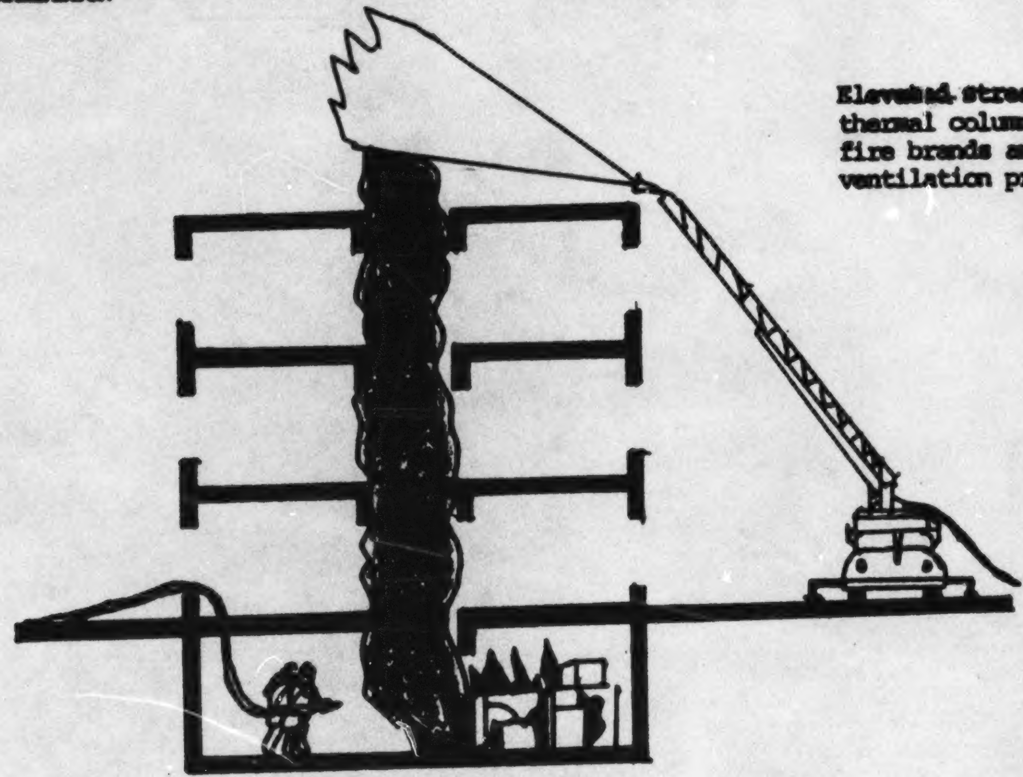
DOWNWARD VERTICAL EXTENSION



Through floors and ceilings by direct flame contact

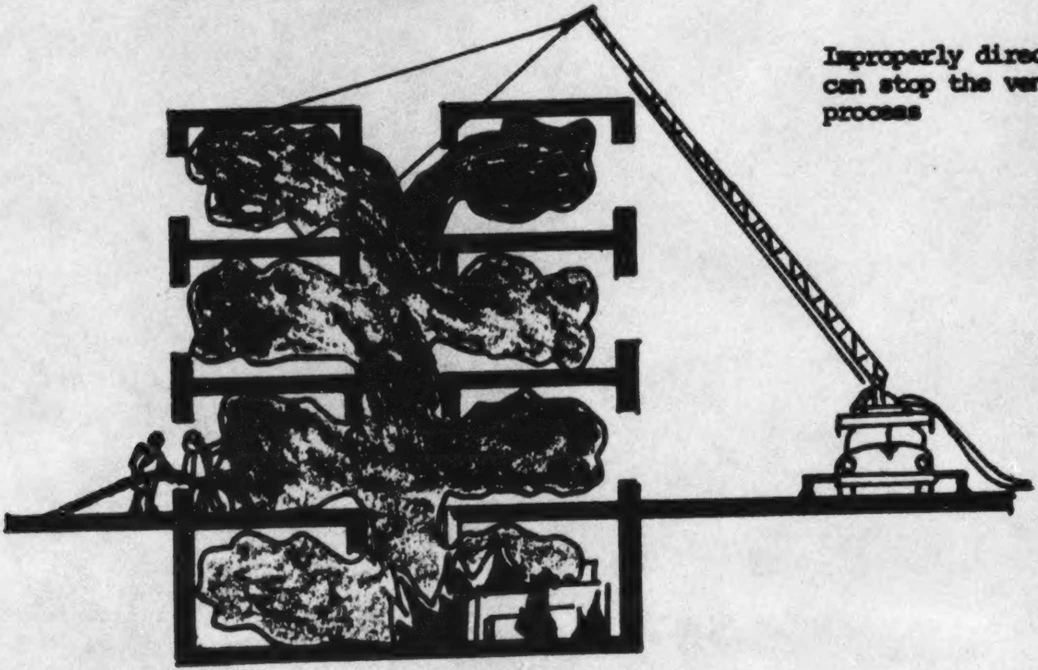
Sparks and burning material falling through cracks and openings in floor

Collapse of floors and roofs



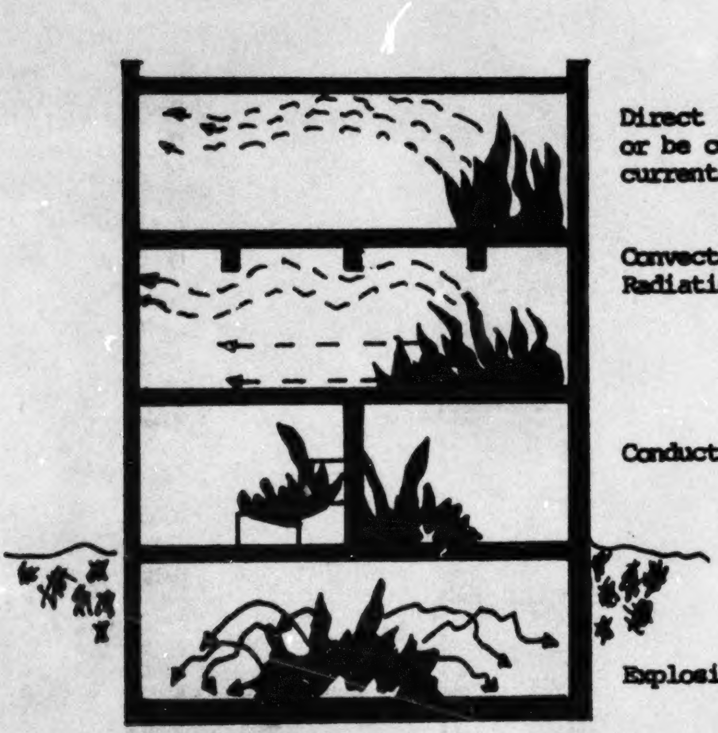
Elevated stream cools thermal column, extinguishes fire brands and aids the ventilation process

VENTILATION AND ELEVATED STREAMS



Improperly directed stream can stop the ventilation process

HORIZONTAL EXTENSION

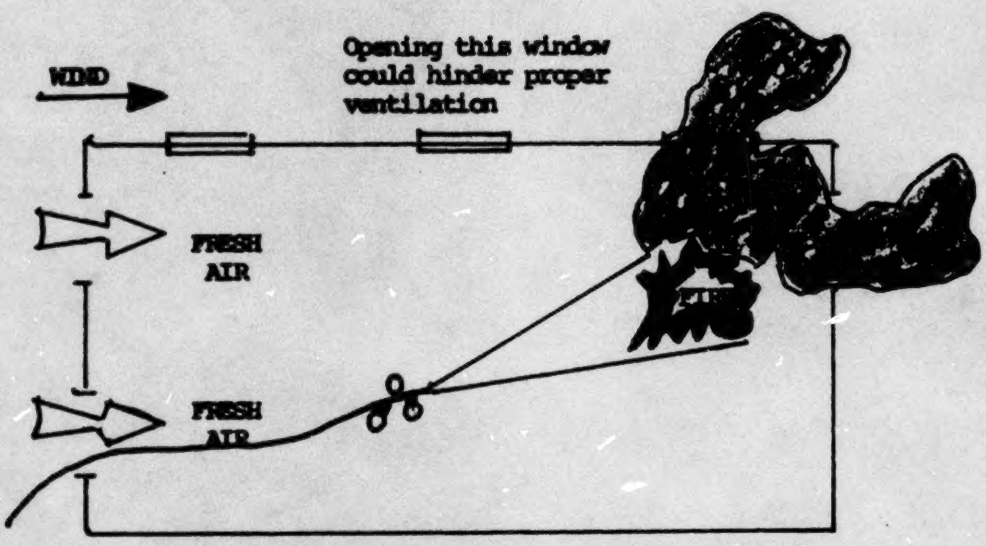


Direct flame contact
or be convected air
currents

Convected air currents,
Radiation and flame contact

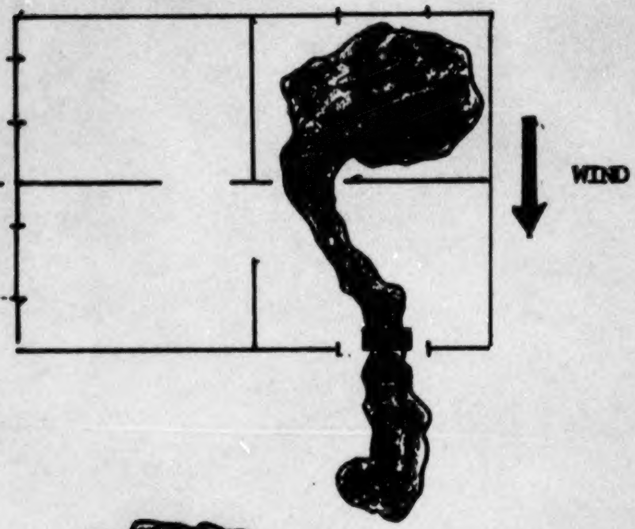
Conduction of heat

Explosion

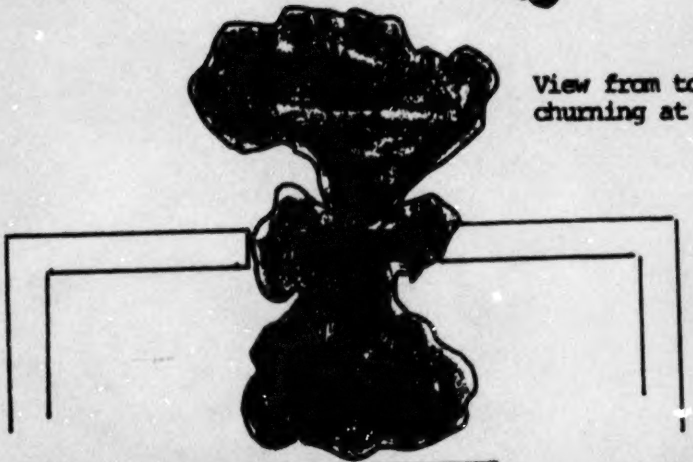

WIND
Opening this window could hinder proper ventilation
FRESH AIR
FRESH AIR

If the indicated window were opened, the wind might create a venturi effect, drawing through that window both fresh air (from the openings on the left) and smoke from the fire.

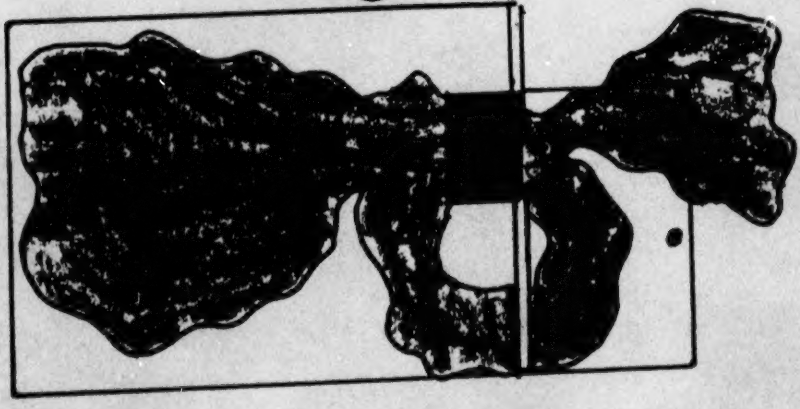
Even if the venturi effect was not very strong, opening the window would upset the relative positive pressures, hindering ventilation.



When possible direct forced ventilation in the same direction as the wind.

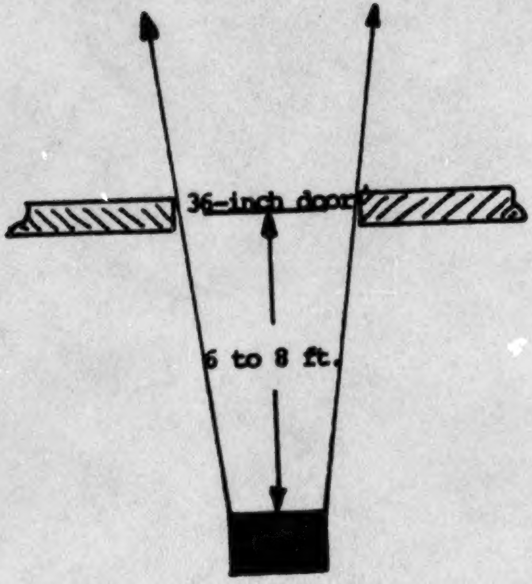


View from top, showing churning at window.

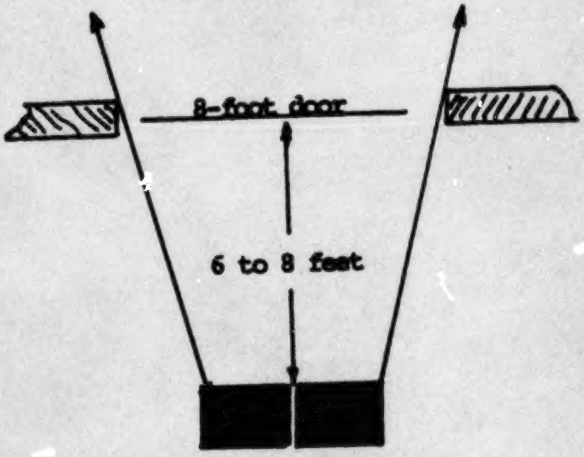


View from side showing chruning in doorway.

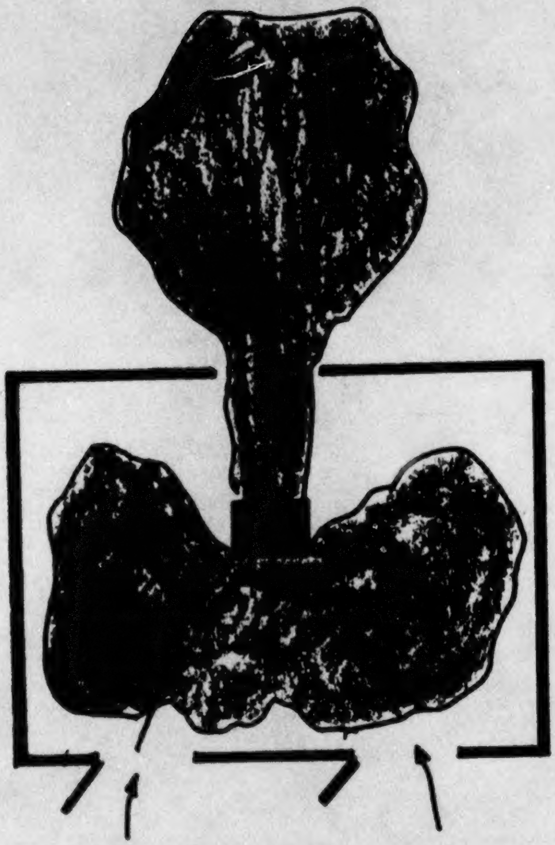
PLACEMENT OF SMOKE EJECTORS


36-inch door
6 to 8 ft.

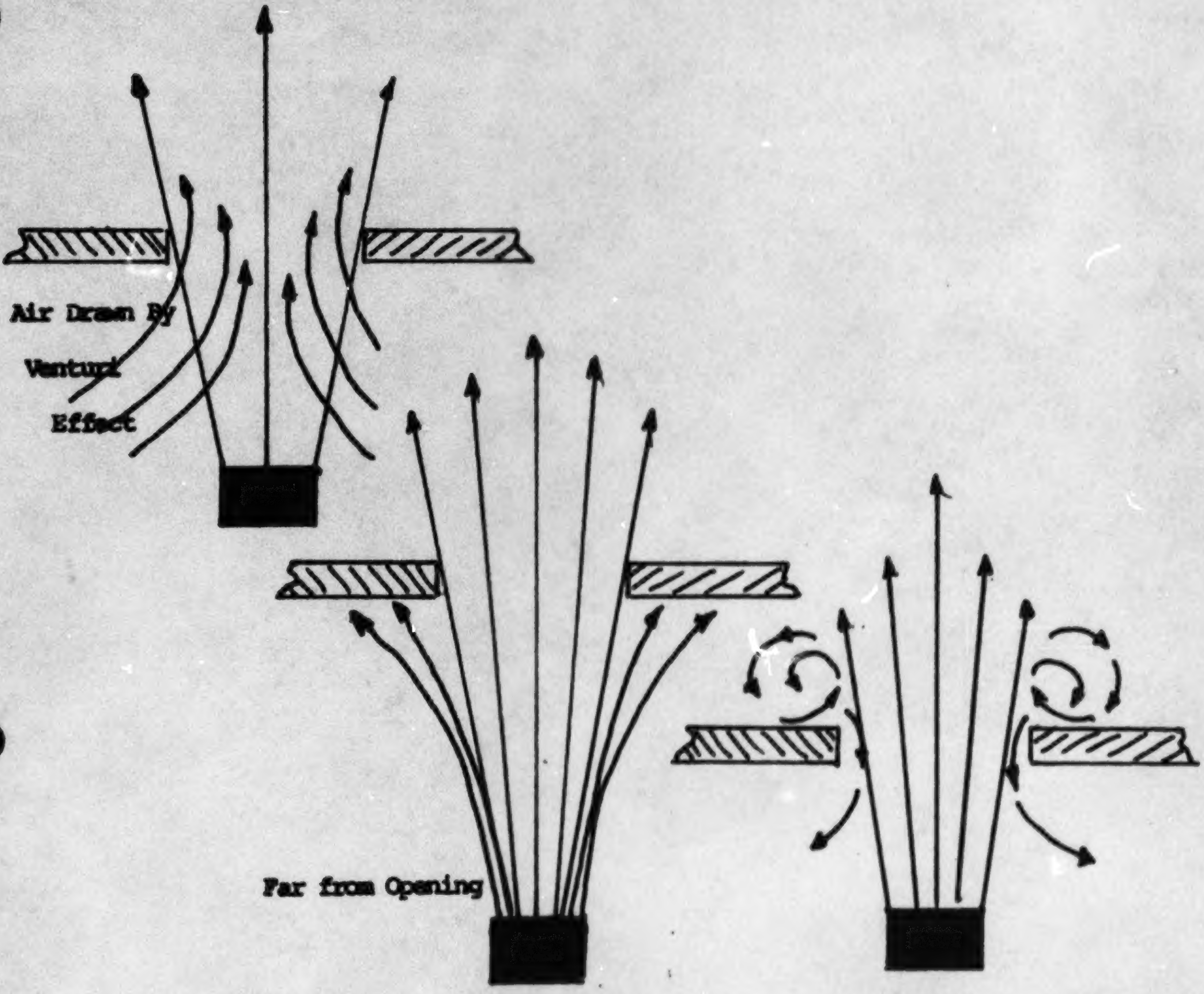
The width of the door and the ejector determine the necessary distance between the two for a good venturi effect.


8-foot door
6 to 8 feet

If the doorway is very wide, more than one ejector may be necessary.

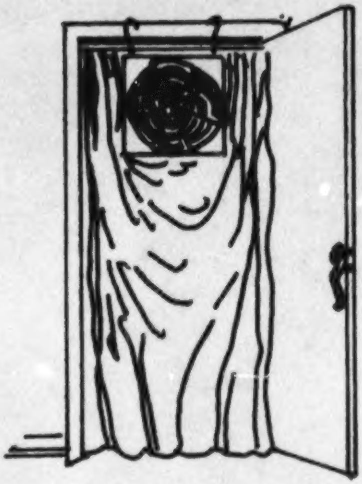


Typical placement for venturi effect.
Note openings for replacement air.

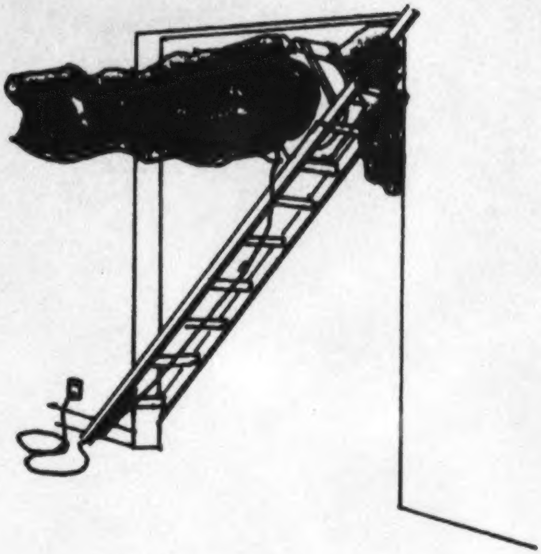

Air Drawn By
Venturi
Effect
Far from Opening

If fan is placed too close to the opening, recirculation (churning) is possible.

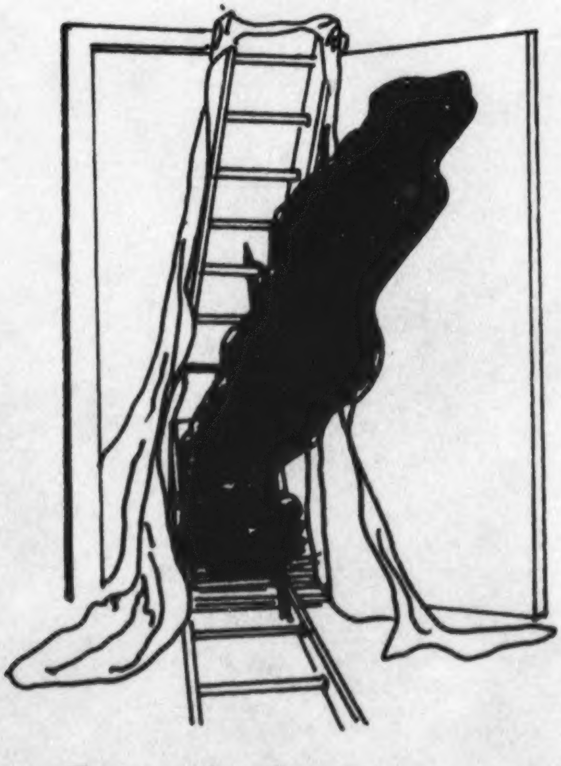
SMOKE EJECTOR PLACEMENT



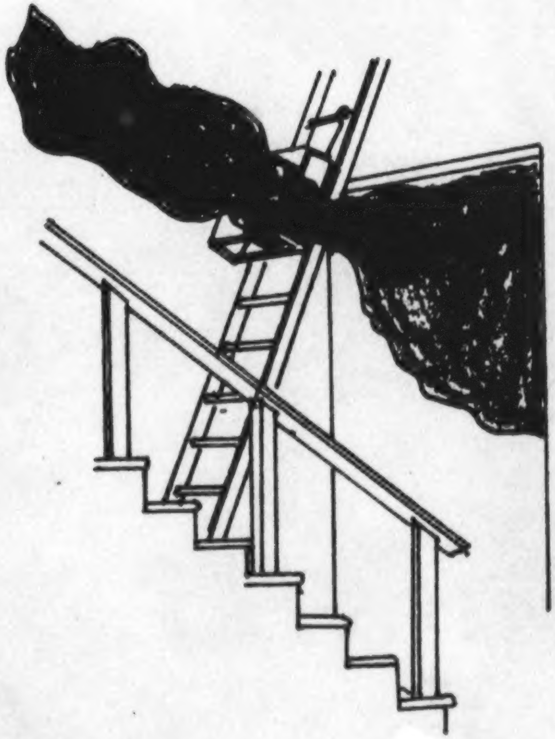
Cover the area around the ejector. to prevent churning and to obtain maximum ejection.



Hall or archway placement

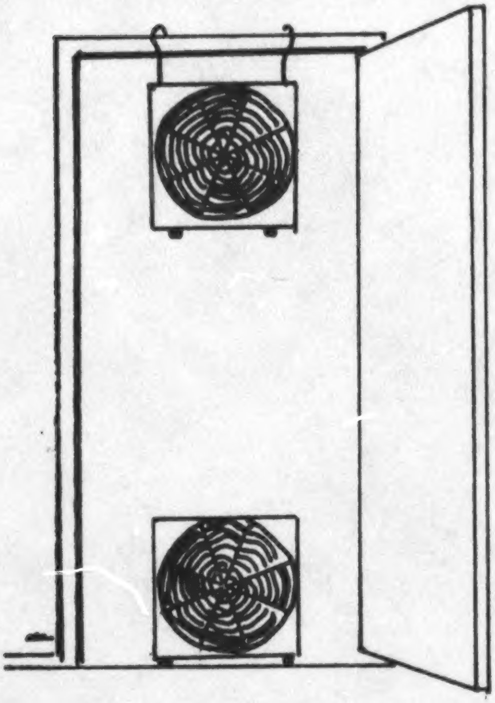


Floor opening placement

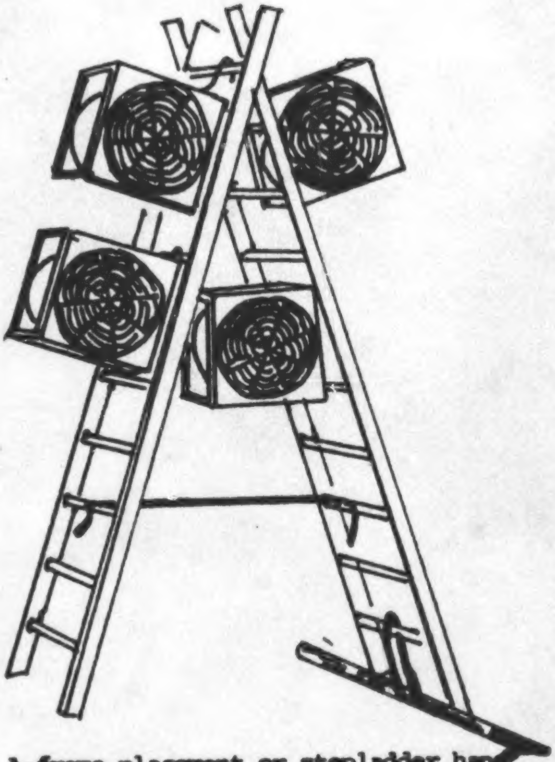


Stairwell placement

SMOKE EJECTOR PLACEMENT

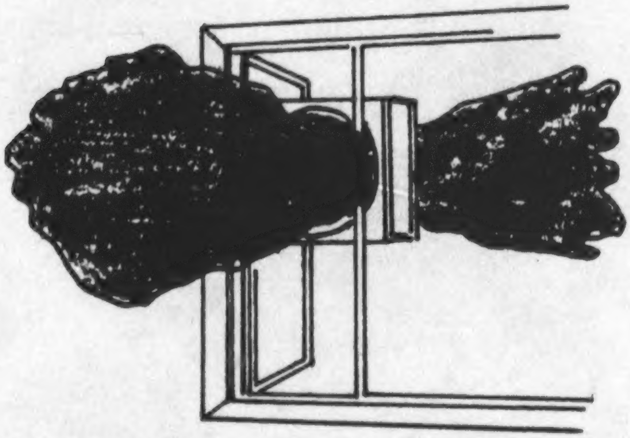


There are several means by which a smoke ejector can be placed in a doorway.

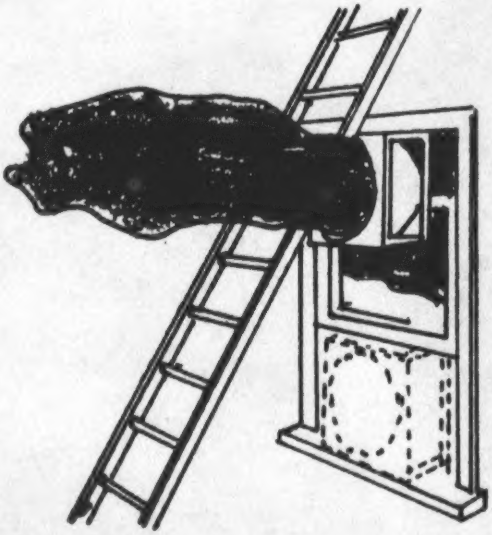


A-frame placement or stepladder hang.

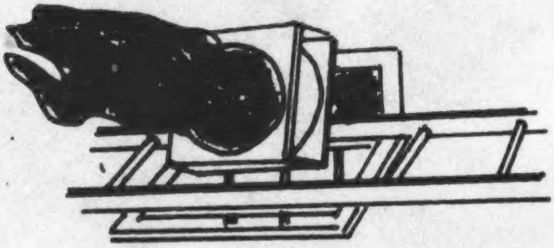
Placement in casement window



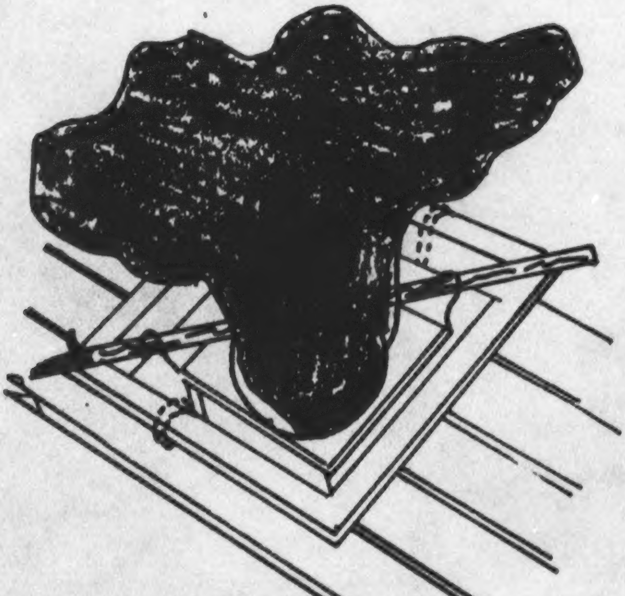
Ladder placement for window



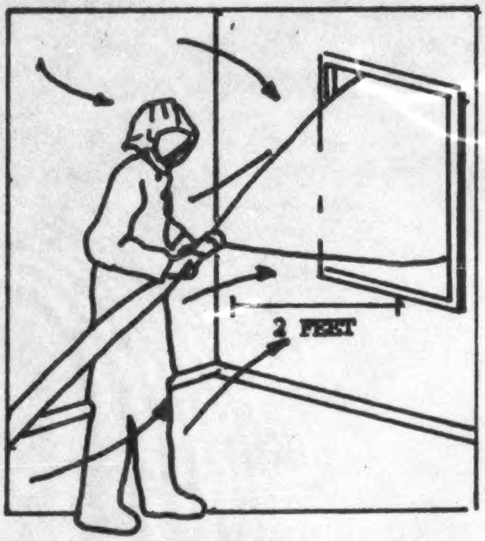
SMOKE EJECTOR PLACEMENT



Window wall placement



Scuttle hanger placement



When using a fog stream to ventilate an area, the nozzle should be about two feet from the opening and the pattern should cover 85 to 90 percent of the opening.